MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXIX JANUARY–FEBRUARY, 1937 NO. 1

HISTORICAL BACKGROUND OF THE MYCOLOGICAL SOCIETY OF AMERICA

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(WITH PORTRAIT AND 5 FIGURES)

Five years ago, in December, 1931, at New Orleans, the Mycological Society of America was voted into existence. Our business session this morning recalls clearly the first meeting of the Society the following winter, when here at Atlantic City at the Hotel Traymore, December 28, 1932, we completed our organization and adopted Mycologia as our official organ of publication. In the few years that have followed, the advantages that are ours as members of an exclusively mycological society have become increasingly manifest. Doubtless in another decade our younger members will have come to regard these advantages as their natural heritage, knowing little of and giving little thought to the problems which confronted American mycologists in earlier years.

Having been long interested in the history of mycology, having served as an officer of our Society during these first five years through what I am pleased to call its formative period, and with the thought that our fifth anniversary should not pass wholly unnoticed, I have prepared for this occasion a paper entitled, Historical Background of the Mycological Society of America. It

[1] Address of the Retiring President of the Mycological Society of America, given at the Atlantic City meeting, December 29, 1936.

[MYCOLOGIA for November–December (28: 497–633) was issued December 1, 1936]

has interested me to review the activities of the Mycological Section of the Botanical Society of America, from which our Society took origin, and to learn all that I could of the older American Mycological Society which lost its identity in 1906 by merging with the Botanical Society. And in order that the record of the organized activities of American students of the fungi might be made more complete I have brought together the pertinent available information concerning the national organizations of wider scope with which mycologists were affiliated during earlier years. It has not seemed to me desirable to incorporate material concerning local societies, though some of them have existed for many years and have had a very considerable influence. Presenting the material in chronological sequence, I shall endeavor to picture the changing situation, which has confronted American mycologists throughout the years as they have sought to meet for consideration of their mutual problems and for presentation of the results of their research. In closing I shall indicate the events which led to the formation of our Society, and shall sketch briefly the essential features of the first five years of its history. I trust that you will regard this subject as appropriate for the address required by the Society of its Retiring President.

ASSOCIATION OF AMERICAN GEOLOGISTS AND NATURALISTS

Nearly one hundred years ago on the second day of April, 1840, eighteen men, interested primarily in geology, held a meeting in the rooms of the Franklin Institute in Philadelphia, which was to have a far reaching influence on the development of science in this country (**1**, p. 9; **2**, vol. 52, p. 15). Impressed by the need for coöperation among American scientists, they unanimously resolved to organize themselves into a national association to be called The Association of American Geologists. Though ten of these eighteen charter members were residents of Philadelphia, the others represented the states of New York, New Jersey, Massachusetts, Connecticut, Virginia, and Michigan. At their third meeting in 1842, at the time of adoption of a constitution and by-laws, the name of the organization became The Association of American Geologists and Naturalists. Its objectives were then stated to be "the advancement of geology and the collateral

branches of natural science and the promotion of intercourse between those who cultivate them" (**1**, p. 77). At that time the membership of the Association had grown to seventy-seven and a volume of Transactions covering the first three meetings was published. The Association was in existence only eight years. Its recorded programs indicate that the interests of its members were predominatingly geological. Botanical material was presented, some of it on fossil plants, but so far as I have been able to determine no dissertation was ever given on any mycological subject. Our only interest in the organization lies in the fact that in September, 1847, in Boston at the eighth and last meeting of the Association a resolution was adopted by which the body agreed to resolve itself into an organization of wider scope to bear the name American Association for the Advancement of Science.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The first meeting of the Association under the new name was held in the rooms of the Academy of Natural Sciences at Philadelphia, September 20, 1848. Rules adopted there state: "The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States; to give a stronger and more general impulse, and a more systematic direction to scientific research in our country; and to procure for the labours of scientific men, increased facilities and a wider usefulness."

The list of 461 charter members published in the Proceedings of the first meeting contains the names of several botanists including those of John Torrey and Asa Gray, but no botanical material appeared on the program the first year. At this first meeting a Section of Natural History and Geology was organized, and Professor Louis Agassiz was selected to preside (**2**, vol. 1, p. 26). He immediately suggested that at each day's session a new chairman be chosen, in order that no individual be wholly prevented from attending other sections. That procedure was followed thereafter for a considerable period of years.

At the second meeting, held at Cambridge, Massachusetts, in August, 1849 (**2**, vol. 2, p. 12), the first botanical paper was presented before the Association. It was read by Professor Asa

Gray for the author, Major Benjamin Alvord of the United States Army, and dealt with *Silphium laciniatum*, a plant of the western plains, in which the leaves were said to be so oriented as to point always exactly north or south. This definite polarity was regarded by the Major as due in some way to the action of magnetism, and he applied the name polar plant. He explained that the plant had been called to his attention by the well known scout Major Nathan Boone, son of the celebrated Daniel Boone. Pro-

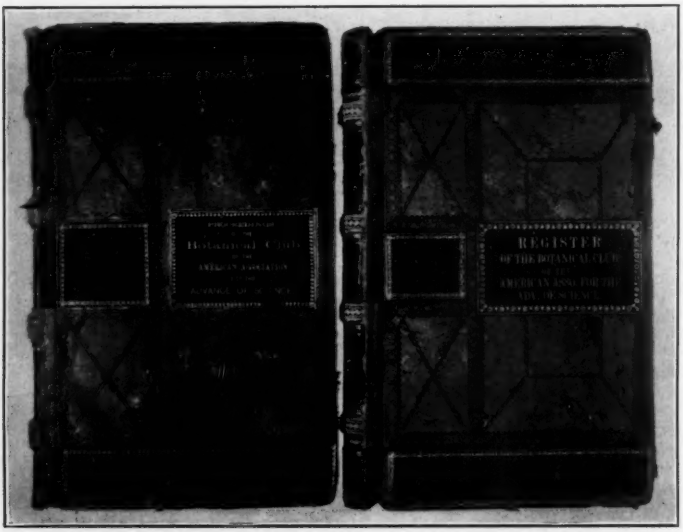


FIG. 1. Proceedings and Register of the Botanical Club of the American Association for the Advancement of Science. Large leather-bound books used throughout the entire life of the organization.

fessor Gray, having grown the plant in his botanical garden at Cambridge, and having failed to observe the polarity claimed for the species, was inclined to disregard the Major's observations.

At the third meeting of the Association held at Charleston, South Carolina, in March, 1850, the first paper containing mycological material made its appearance on the program (2, vol. 3, pp. 2–17). Its author, H. W. Ravenel, is known to all of us as the

early collector who distributed the exsiccati sets Fungi Americani and Fungi Caroliniani. In a paper entitled "Catalogue of Plants Inhabiting the Vicinity of the Santee Canal, South Carolina," he reported before the Association the collection of more than 2400 species of plants of all groups. He stated that he had found approximately 1000 fungi and 175 lichens, his figures being indefinite because much of the material was as yet unidentified. He says: "Although my attention has been chiefly directed for the last three years to the collection and examination of the fungi, I cannot doubt, from the ease with which new forms are continually added to my collection, the great number of different species which spring up in the same locality in different seasons, that the present number may, in the course of time, be easily doubled."

At the fifth meeting in 1851, George C. Schaeffer of Danville, Kentucky, gave a paper entitled "On the Detection of Organic Miasm in the Air." He says: "It is now the opinion of most chemists who have investigated the subject that malaria is caused, not by peculiar states of the atmosphere, but by some complex organic compound floating in it" (**2**, vol. 5, p. 239).

Twenty years passed before in 1870 the second mycological paper made its appearance (**2**, vol. 19, p. 287). In that year a lengthy but unimpressive dissertation was given bearing the title "Investigation of the Development of the Yeast or Zymotic Fungus." At the end of an additional ten years, in 1880, Thomas J. Burrill presented one of the first papers before the Association in the field of bacteriology, discussing his epoch-making work on fire-blight of pears and apples under the general title of "Anthrax of Fruit Trees" (**2**, vol. 29, p. 583). Byron D. Halsted appeared on the same program with a paper entitled "An Investigation of Peach Yellows" (**2**, vol. 29, p. 605). During these first thirty-two years of the Association's existence a total of only 48 contributions in the broad field of botany were made. The reader who scans the pages of the Proceedings of the earlier years is impressed by the fact that workers were few and papers often lacking in the precise scientific method of presentation which we have come to expect today. Nevertheless, the student with the historical turn of mind finds much to interest him and is sometimes afforded amusement.

For more than fifty years the annual meetings were held during the summer (2, vol. 52, p. 16). In the earlier years transportation facilities did not permit workers in remote regions to get together in midwinter. Most of the early meetings were held along the Atlantic seaboard, often in smaller cities than would now be selected, such as Salem, Massachusetts, Troy and Saratoga, New York, and Burlington, Vermont. The fifth meeting ventured as far west as Cincinnati and it is interesting to read of the astonishment of the members of the committee at finding adequate facilities where frontier conditions in the forest had been expected (2, vol. 5, p. 244). Nevertheless, it was not until seventeen years later, at the close of the Civil War, that the first Chicago meeting was held in August, 1868, marking the farthest point west for meetings held up to that date. Chicago, with a population of 200,000, had then just begun to forge ahead of Cincinnati. Two years earlier in 1866, with the bridging of the Hudson River at Albany, it became possible to journey from New York to Chicago by rail by changing trains and railways at several intermediate points. The first through train between the two cities did not run until 1875.

SECTION F

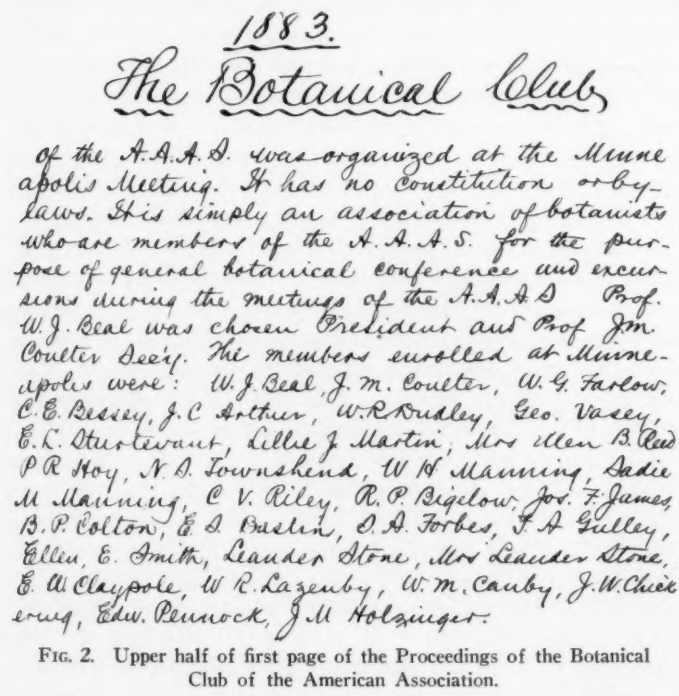
The Association during its earlier life, with a relatively small membership, was much less definitely organized than is the case today. The Section of Natural History and Geology, recognized at the first meeting in 1848, persisted for a period of years as an indefinite thing without permanent organization or annual officers. At times it embraced chemistry. It was not until 1882 that increase in membership and in the number of subject matter groups led to the formation of a larger number of sections designated by letters of the alphabet as at present. That year Section F was established for biology, including both botany and zoölogy, and excluding such borderline fields as microscopy, histology, anthropology, and geology which were assigned to other sections (2, vol. 31, p. 423). With the erection of this permanent organization, election of annual officers began. In Section F the offices of chairman and secretary were established. They were filled in alternate years by botanists and zoölogists respectively. The

botanists who served as chairman of the section were W. J. Beal (1883), T. J. Burrill (1885), W. G. Farlow (1887), G. L. Goodale (1889), and J. M. Coulter (1891), while the position of secretary was filled by C. E. Bessey (1884), J. C. Arthur (1886), B. E. Fernow (1888), J. M. Coulter (1890), and B. D. Halsted (1892). Zoölogical papers usually predominated on the programs but the section showed a gradually increasing botanical interest. In the broad field of botany specialization was on the increase, and a larger number of botanists with limited interests were attending the meetings. Though prior to the formation of Section F, in 1882, only two papers dealing with any phase of mycology had been presented before the Association throughout the thirty-four years of its existence, papers dealing with the fungi now became less uncommon. In 1883 W. G. Farlow discussed "The Spread of Epidemic Diseases in Plants" using *Peronospora viticola, P. Halstedii,* and *Puccinia malvacearum* as outstanding examples of causal organisms (**2**, vol. 32, p. 307). In 1885 he gave "Notes on Some Injurious Fungi of California" (**2**, vol. 34, p. 300), in 1886 presented "The Development of the Gymnosporangia of the United States" (**2**, vol. 35, p. 237) and in 1887 selected as the subject of his vice-presidential address before the section "Vegetable Parasites and Evolution" (**2**, vol. 36, p. 233). Meanwhile other mycological contributions were being made. In 1885 J. C. Arthur presented cultural proof of the earlier hypothesis of Burrill that "bacteria are the direct cause of the disease of trees known as pear blight" (**2**, vol. 34, p. 295), and Theobald Smith appeared on the program with several bacterial contributions.

THE BOTANICAL CLUB OF THE AMERICAN ASSOCIATION

In 1883, the year following the organization of section F, the Association met at Minneapolis. For botanists it was the most important meeting which had been held in America up to that date. We quote the words of John M. Coulter who reported on it in the Botanical Gazette (**6**, vol. 8, p. 291). He says: "This meeting was a memorable one for botanists, there being more in attendance than ever before, and for the first time botanical papers were in the majority in the section of biology. But after all, the interest at such a time is not so much in the papers read as in the personal

contact of the workers who may long have known each other but never had met, and for whom the clasp of the hand and the glance of the eye cements a friendship already formed. At such times beginners meet with the leaders whose names are household words, and find them genial, hearty, whole-souled men, with a cheering word for all, and they return with fresh zeal for their work."



1883.

The Botanical Club

of the A.A.A.S. was organized at the Minneapolis Meeting. It has no Constitution or by-laws. It is simply an association of botanists who are members of the A.A.A.S. for the purpose of general botanical conference and excursions during the meetings of the A.A.A.S. Prof. W.J. Beal was chosen President and Prof. Jn. Coulter Secy. The members enrolled at Minneapolis were: W.J. Beal, J. M. Coulter, W.G. Farlow, C.E. Bessey, J.C. Arthur, W.R. Dudley, Geo. Vasey, E.L. Sturtevant, Lillie J. Martin, Mrs Ellen B. Reid P.R. Hoy, N.A. Townshend, W.H. Manning, Sadie M. Manning, C.V. Riley, R.P. Bigelow, Jos. F. James, B.P. Colton, E.A. Bastin, S.A. Forbes, F.A. Gulley, Ellen E. Smith, Leander Stone, Mrs Leander Stone, E.W. Claypole, W.R. Lazenby, W.M. Canby, J.W. Chickering, Edw. Pennock, J.M. Holzinger.

FIG. 2. Upper half of first page of the Proceedings of the Botanical Club of the American Association.

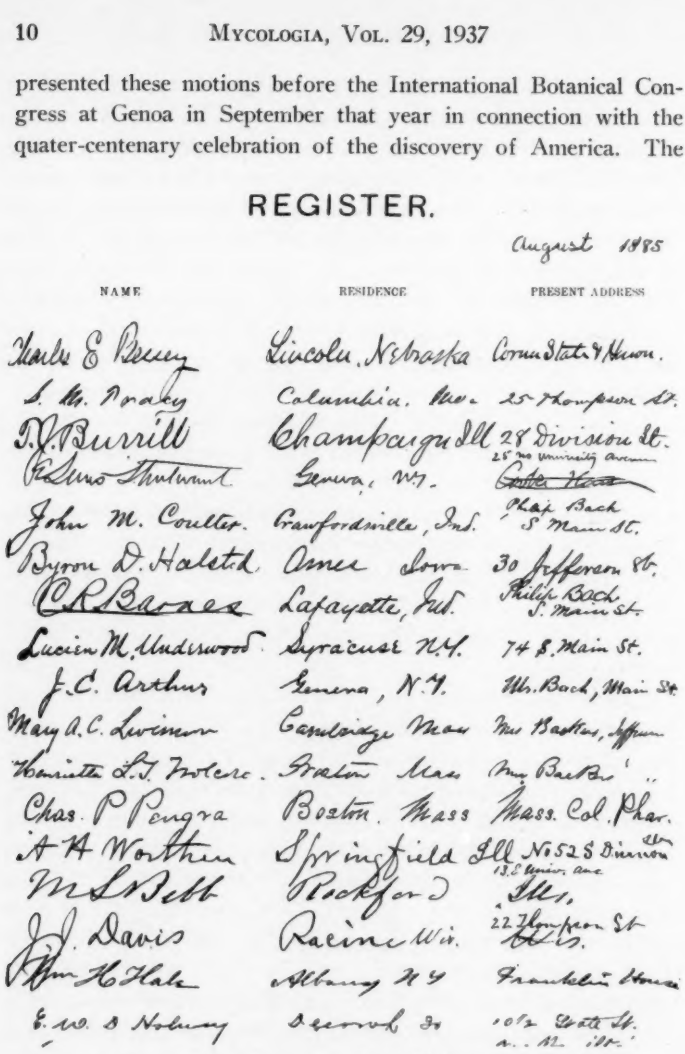
Botanical zeal ran so high that it culminated in the formation of an American botanical club (**13**, p. 1), established to foster general botanical conferences and excursions during the meetings of the American Association. Its membership consisted thereafter of the botanists attending these meetings. Formal organization with the adoption of a constitution and by-laws was never undertaken. Thirty members, representing thirteen different states, enrolled the first year at the Minneapolis meeting. The

Club elected W. J. Beal as its first president and J. M. Coulter as its first secretary. The following year at the Philadelphia meeting it entered enthusiastically on its work (**6**, vol. 9, p. 156). The local botanists of Philadelphia presented the organization with a large leather-bound blank register in which for many years thereafter it was the custom for all individuals attending the sessions to sign their names (FIG. 1). Its pages for those early years bear the signatures of Asa Gray, E. W. D. Holway, F. Lamson-Scribner, N. L. Britton, Charles Bessey, T. J. Burrill, L. M. Underwood, J. C. Arthur, and other outstanding botanists of the period (FIG. 3). An essentially identical companion volume was purchased to receive the Proceedings of the meetings (FIG. 1, 2). The Botanical Club was active for more than twenty years (**4**, vol. 13, p. 108; vol. 23, p. 350; **6**, vol. 9, p. 156; vol. 45, p. 424; **13**). It held its last meeting in Philadelphia in 1904, J. H. Barnhart being its last secretary and treasurer. The two volumes constituting its Proceedings and Register were then deposited with the Botanical Society of America, and became a part of the archives of that Society. They are now in the possession of its secretary.[2]

Though the Botanical Club was not officially a subdivision of the American Association its existence was occasionally recognized by that body. In 1888 abstracts of papers presented before the Club were printed in the Proceedings of the Association (**2**, vol. 37, p. 396) and in 1892 its activities were listed in the printed program. On several occasions the Club took action of considerable significance. In August 1892, at Rochester, N. Y., the Rochester Motions were adopted. They constitute the first rules of botanical nomenclature framed by a national group of American botanists. By their terms the Paris code of 1867 was accepted except where it conflicts with certain specified points. The law of priority was proposed as the "fundamental principle of botanical nomenclature," and the starting point was designated as the first edition of the Species Plantarum of Linnaeus of 1753. L. M. Underwood, serving as the delegate of the Botanical Club,

[2] At the Atlantic City meeting the Council of the Botanical Society of America voted to deposit these volumes permanently in the library of The New York Botanical Garden with the restriction that they be not loaned.

presented these motions before the International Botanical Congress at Genoa in September that year in connection with the quater-centenary celebration of the discovery of America. The


REGISTER.

August 1875

NAME	RESIDENCE	PRESENT ADDRESS
Charles E Bessey	Lincoln, Nebraska	Comm State Y Union.
S. M. Tracy	Columbia. Miss.	25 Thompson St.
T. J. Burrill	Champaign Ill	28 Division St.
[illegible] Thurlow	Geneva, N.Y.	25 [illegible]
John M. Coulter.	Crawfordsville, Ind.	Phi Kap Back S. Main St.
Byron D. Halsted	Ames Iowa	30 Jefferson St.
C R Barnes	Lafayette, Ind.	Phi Kap Back S. Main St.
Lucien M. Underwood	Syracuse N.Y.	74 S. Main St.
J.C. Arthur	Geneva, N.Y.	Mrs. Beach, Main St.
Mary A.C. Livingston	Cambridge Mass	Mrs Barbour, Jeffers
Henriette L.T. Wolcott	Groton Mass	Mrs Barbour
Chas. P Pengra	Boston. Mass	Mass. Col. Phar.
A H Worthen	Springfield Ill	No 52 S Division St 13 E Union Ave
M L Bebb	Rockford	Ills.
J. J. Davis	Racine Wis.	22 Thompson St Ills.
Wm H Hale	Albany N.Y.	Franklin House
E. W. S Nobury	Concord Mass	105 State St. [illegible]

FIG. 3. Upper portion of a page of the Register of the Botanical Club of the American Association.

motions and others submitted at Genoa initiated the revision of the Laws of DeCandolle which was completed at Vienna thirteen years later to give us the International Code. At the Washington meeting of the Club in 1903 a nomenclature commission was

appointed by the Club which drafted the set of rules which soon afterwards were adopted as the basis for a revision which became the American Code of Nomenclature (**4**, vol. 31, p. 249). In 1893 a committee of the Club prepared a check list of great usefulness which was published as volume 5 of the Memoirs of the Torrey Botanical Club with the title "List of Pteridiophyta and Spermatophyta Growing Without Cultivation in Northeastern North America." The Club had the distinction of being our first national botanical organization. Mycological papers appeared on its programs in increasing number yearly, but no effort was ever made to segregate them in a special program or to form a mycological section of the Club.

SECTION G

Section F of the American Association, established for biology in 1882, embraced both botany and zoölogy for eleven years. In 1893 (**2**, vol. 42, pp. 236–264) it became exclusively zoölogical, when the new Section G was formed for botany. The change in organization was effected at the Madison meeting held in August of that year. This meeting was most outstanding for botanists in that it was also the occasion for the holding of the Madison Botanical Congress and saw the origin of the Botanical Society of America.

The World's Columbian Exposition, commonly called the Chicago World's Fair, was held during the summer of 1893. Extensive botanical exhibits had been set up in the Horticultural Building and in several of the State buildings, and American botanists hoped that many foreign botanists would attend. The proximity of Madison to Chicago led to the plan to hold a Botanical Congress that summer in Madison in conjunction with the meeting of the American Association with the thought that it would attract foreign botanists in sufficient numbers to give it an international character. Actually few foreign botanists attended, and the meeting was finally designated not as an International Botanical Congress, but merely as the Madison Botanical Congress (**6**, vol. 18, pp. 350, 357, vol. 19, p. 386).

Section G, entering its first year of existence at Madison that summer, had as its first chairman Charles E. Bessey. In introducing his address, which dealt with Evolution and Classification,

he expressed deep satisfaction that for the first time in the history of the Association the botanists were met officially as a separate group (**2**, vol. 42, p. 237). Today the section has endured 43 years. It now serves chiefly as the official unit of the Association about which the various specialized botanical societies cluster, and through which their affiliation with the mother organization is accomplished. The program of Section G itself has been reduced to the minimum, and consists of the annual joint program with the botanical societies with which you are all familiar.

The Association, from its origin in 1848 until 1902, held all of its annual meetings in the summer. The practice of meeting at midwinter instead began with the 52nd meeting at Washington in December 1902, and has persisted to the present. Because the pleasant and profitable features of the summer excursions were missed an additional summer meeting was held at Ithaca, N. Y., in 1906. Since then the practice of holding two annual meetings, one during the Christmas holidays and one at midsummer, has been followed. The present meeting is the 99th. Next summer at Denver, a special program will commemorate the holding of the 100th meeting. The Association is now in its 89th year. During its life only seven botanists have served as its president. They were John Torrey (1855), Asa Gray (1871), G. Lincoln Goodale (1890), William G. Farlow (1904), Charles E. Bessey (1911), John M. Coulter (1918), and Liberty Hyde Bailey (1926). Only one of these, Doctor Farlow, may be listed as a mycologist.

BOTANICAL SOCIETY OF AMERICA

The Madison meeting of August 1893, at which Section G was established, also saw the birth of our first national botanical society, the Botanical Society of America (**6**, vol. 18, pp. 347, 348). For some years American botanists had wished to form such a society, but opinions had differed as to the feasibility of the attempt and as to the type of organization desired (**4**, vol. 19, p. 294; **6**, vol. 17, p. 289). At Madison the Society came into being through formal action of the older Botanical Club of the American Association (**4**, vol. 21, p. 411; **6**, vol. 19, p. 388; **7**, Nos. 1, 2, 3, 11, 12, 13, 16, 19, 20). The Club elected ten men, admittedly prominent and active in the field, and instructed them to meet

and select fifteen others. It was the intent that the twenty-five individuals thus chosen should constitute the charter membership (**4**, vol. 20, p. 373; **6**, vol. 18, p. 368). Actually, five of those selected declined membership. The names of the twenty who accepted follow:

Joseph C. Arthur	Byron D. Halsted
George F. Atkinson	Arthur Hollick
Liberty Hyde Bailey	Conway MacMillan
Charles R. Barnes	Benjamin L. Robinson
Charles E. Bessey	Charles S. Sargent
Nathaniel Lord Britton	John Donnell Smith
Elizabeth G. Britton	Roland Thaxter
John M. Coulter	William Trelease
Frederick Vernon Coville	Lucian M. Underwood
Edward L. Greene	William P. Wilson

The founders of the Society felt that membership should be restricted to those who had published outstanding work and were actively engaged in botanical investigation. The society from the beginning was thus somewhat honorary in nature, and for years it admitted to membership only the older and better known botanists. Meanwhile, the Botanical Club continued its own existence, and was regarded as the more inclusive and democratic group. At the meetings of the American Association in the nineties formal more or less competing programs were held by the Botanical Club, Section G, and the newly formed Botanical Society.

Organization of the Botanical Society of America was completed at the Brooklyn meeting of the Association in August, 1894 (**8**), and its first annual meeting was held at Springfield, Mass., the following summer. A brief historical sketch of the society, with emphasis on its origin and early activities, is given by Atkinson in Publication 11 of the Society. At the end of five years the membership had increased to thirty-three. A definite effort was made to keep the group small and distinguished. Annual dues were twenty-five dollars. Newly elected members were given the status of associate, and were denied the privileges of voting and

holding office. Two of the charter members, Liberty Hyde Bailey and Roland Thaxter, tendered their resignations in 1898 after a brief four years of membership. Well known mycologists admitted during the early years of the Society were E. A. Burt, R. A. Harper, Charles Peck, W. T. Swingle, F. E. Clements, and Hermann von Schrenk. No attempt was made to publish a society journal.

In 1898, five years after the Botanical Society of America came into existence, another competing national botanical society, which took the name of Society of Plant Morphology and Physiology, was established. It held its meetings independent of the American Association. Its first president, W. G. Farlow, had declined charter membership in the Botanical Society of America. Its membership was somewhat larger than that of the Botanical Society and less effort was made to maintain exclusiveness. A number of prominent botanists were affiliated with both societies (**7**, No. 20, p. 45).

It may be of interest to mention in passing that the Bulletin of the Torrey Botanical Club, the first number of which appeared in January, 1870, was 23 years old when the Botanical Society of America was born (**4**, vol. 1, No. 1, 1870). The Botanical Gazette was almost as old, dating from 1875 when John Coulter began its publication privately at Hanover, Indiana, under the name Botanical Bulletin (**5**, vol. 1, No. 1, 1875).

AMERICAN MYCOLOGICAL SOCIETY

Our first national mycological society, the American Mycological Society, was organized December 26, 1903, at the second St. Louis meeting of the American Association (**9**, vol. 10, p. 46). Preliminary arrangements had been made by a committee of three, consisting of F. E. Clements, F. S. Earle, and C. L. Shear, appointed at an informal gathering of mycologists at the preceding Washington meeting in 1902. Roland Thaxter was elected president, F. S. Earle vice-president, and F. E. Clements secretary-treasurer. A report of this first meeting of the Society with a list of the papers read was published in the Journal of Mycology in 1904. The twenty-seven members of the society (**7**, No. 45) were:

Joseph Charles Arthur
George F. Atkinson
Howard J. Banker
Thomas J. Burrill
Edward A. Burt
Mark A. Carleton
Frederic E. Clements
George P. Clinton
Clara E. Cummings
Benjamin M. Duggar
Elias J. Durand
Franklin S. Earle
William Gilson Farlow
Bruce Fink
Edward M. Freeman
David Griffiths
George G. Hedgcock
Edward W. D. Holway
William A. Kellerman
Thomas H. Macbride
Andrew P. Morgan
William A. Murrill
Charles H. Peck
Percy L. Ricker
Cornelius L. Shear
Roland Thaxter
Samuel M. Tracy

Doctor Shear, who served as a member of the organizing committee, has explained to me the reasons for the formation of the new society. The younger mycologists, barred by rigid requirements from membership in the Botanical Society of America, felt that there was little or no place for them except in Section G. The situation is clearly appreciated if reference is made to the membership lists of the Botanical Society where prominent mycologists had to be content with the grade of associate. However, no sooner was the Mycological Society in existence than a number of botanists in the three societies (the Botanical Society of America, the Society of Plant Morphology and Physiology, and the American Mycological Society) expressed a growing conviction that the interests of botanical science as a whole would be more effectively advanced by a single organization. Thereupon a joint reorganization committee was formed with representation from the three societies. The mycologists at their first meeting had anticipated this move and had named a committee on "affiliation with other societies," consisting of C. L. Shear, G. F. Atkinson, and T. J. Burrill. The task of reorganization of the botanists and the preparation of a constitution acceptable to all members proved difficult and negotiations were carried on over a period of months before success was attained.

Meanwhile in December, 1904, the American Mycological Society held its second annual meeting at Philadelphia, elected Charles

H. Peck as President (FIG. 4), re-named F. S. Earle Vice-President, and made C. L. Shear, Secretary-Treasurer. A report of the meeting with a list of the papers presented is given in Science (**10**, vol. 21, p. 748). The third and last meeting of the Society was held in New Orleans in January 1906. In the absence of President Peck, Vice-President Earle presided (**6**, vol. 41, p. 160; **9**, vol. 12, p. 85; **10**, vol. 23, p. 186).

At New Orleans the report of the committee on reorganization of the botanists was accepted by the Society and a new constitution which had been prepared was adopted. By this action the three organizations were united under the name Botanical Society of America. The first president of the Society following this federation was George F. Atkinson. He had held membership in all of the three uniting groups. Today the reorganized Botanical Society of America has existed twenty years. A complete list of its past officers is printed annually in its Yearbook. Its membership, constituting that of the three older societies, totaled at the time of federation in 1906 only 119 botanists. Their names are listed in Publication 28 of the Society, their previous affiliations being indicated. There was little increase in membership of the new society in the years immediately following. The distinction between full membership and associate membership was maintained, and as late as 1909 we find (**7**, No. 39) the resolution adopted that "the Council may at any regular meeting of the Society recommend not more than five associate members for election to membership." No effort was made to broaden the scope of the Society, the applied branches of botany being essentially ignored. It is not surprising, therefore, that, in the same year that this resolution was adopted, the American Phytopathological Society was organized (**10**, vol. 31, p. 746). It began its outstandingly successful life with a charter membership of 130, and a pronouncedly democratic character. The Society was founded at Baltimore in 1908. Its first annual meeting was held the next winter in affiliation with the American Association, at the Harvard Medical School in Boston. Fifty members were in attendance, the first President, L. R. Jones, being in the chair. The membership fee, fixed at one dollar, was not increased until

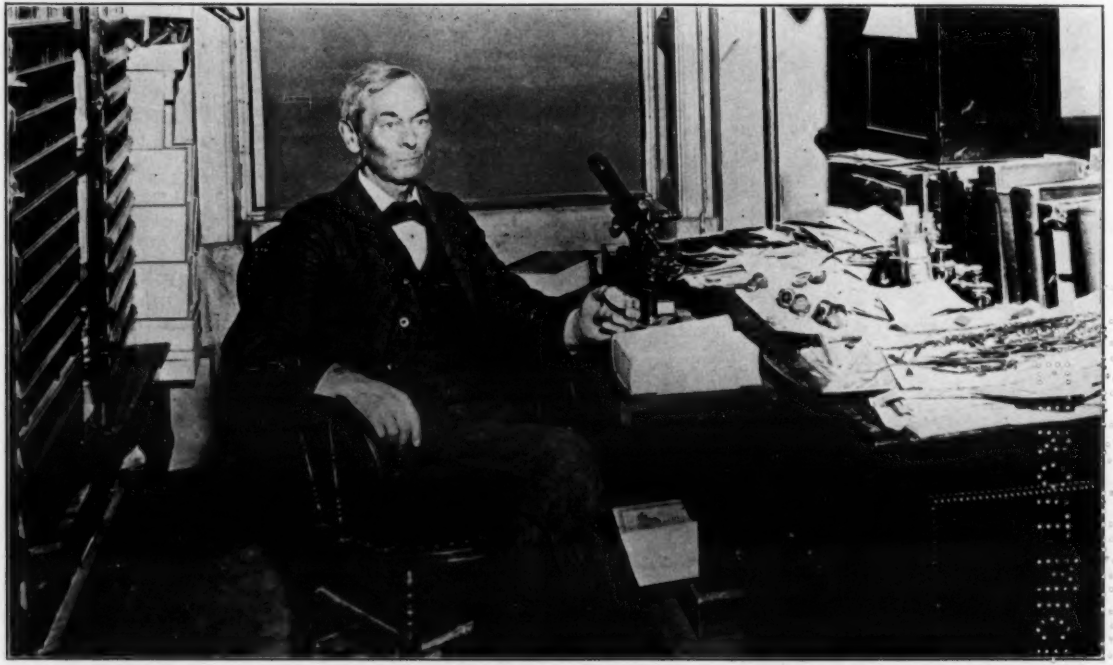


FIG. 4. Charles H. Peck in his office at the State House in Albany, N. Y. Photograph was taken in about 1904, the year of his election as the second President of the American Mycological Society. A photograph of Roland Thaxter, first President of the Society, is omitted because none is available showing him at that period of his life.

the journal, Phytopathology, was established two years later in February, 1911. Last Christmas at St. Louis the 25th birthday of the journal was appropriately celebrated at the Phytopathologists' Dinner. The membership of the Society has now reached a total in excess of 900.

The successful establishment of Phytopathology served to emphasize the need of the Botanical Society of America for its own official organ of publication. The demand that a journal be established grew, bringing with it the practical necessity for an enlarged membership. The reactionary element in the Society was finally over-ruled (**8**) and in January, 1913, after prolonged discussion, the constitution was so broadly emended that practically any individual actively engaged in botanical work might become a member. At the following meeting (**10**, vol. 39, pp. 253), 125 new members were admitted, and a contract was drawn up between the Society and the Brooklyn Botanic Garden which resulted in the establishment of the American Journal of Botany (**11**, vol. 3, pp. 74–76). Its first number appeared in January, 1914. Membership in the Society increased very rapidly, 87 new names being added in 1914, and 146 in 1915. The restricted total membership of 137 in 1909 has in a quarter of a century grown to approximately 1200. Nevertheless, the old point of view died hard, and even as late as 1914 a motion was drafted looking toward the establishment of an "honor grade" of membership to set the elect aside from the crowd. The more liberal viewpoint has prevailed and in 1918 the secretary of the Society in an appeal for increased membership says: "With growth the Society has assumed larger and wider responsibilities, well known to its members, until at the present time it is not alone the privilege, but distinctly the duty of every American botanist to share these responsibilities to our science by assuming the obligations of membership in the Society."

Four years after the establishment of the American Journal of Botany the first number of Botanical Abstracts appeared in September, 1918. In December, 1926, that journal was replaced by Biological Abstracts. The pages of these publications reveal to a startling degree the rapidity of the growth of botanical science in this country and in the world.

MYCOLOGICAL SECTION OF THE BOTANICAL SOCIETY

Increase in membership of the Botanical Society embracing many special interests soon led to the demand for the formation of sections. So many papers were submitted for presentation that subdivision of the membership and simultaneous programs became imperative necessities. In 1916 a Physiological Section was established, in 1917 a Systematic Section, and in 1919 a Mycological Section. Prior to 1919 papers on the fungi had been given largely

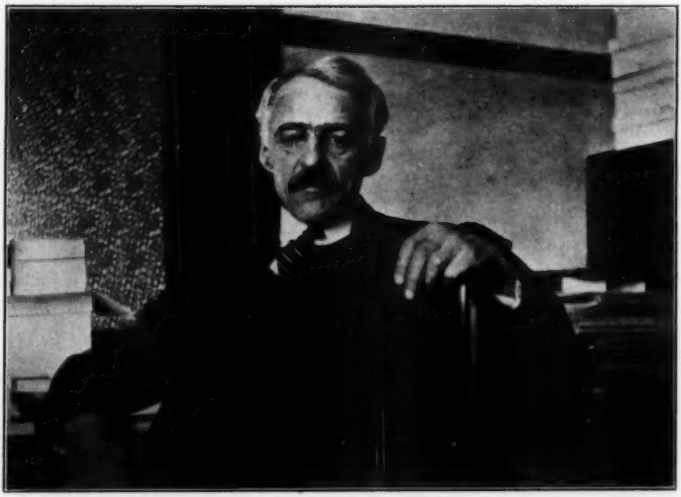


FIG. 5. Calvin H. Kauffman in his herbarium at the University of Michigan. Photograph taken by the author in 1921 the year following that in which he served as the first Chairman of the Mycological Section of the Botanical Society of America.

in a joint session held by the Botanical Society with the American Phytopathological Society.

A petition addressed to the Council of the Society and signed by twenty-five members interested in mycology gained permission to organize the Mycological Section (**7**, No. 75). Organization was effected at St. Louis in 1919, the first program of the Section being given at Chicago in 1920, with C. H. Kauffman (FIG. 5) acting as Chairman (**7**, No. 76, p. 9). The establishment of the

section proved a great stimulus to American mycologists, and resulted in the presentation of an increasing number of mycological papers. The section existed twelve years. Dates and places of meeting and names of officers are given in the accompanying table (**7**, No. 100, pp. 11–13, No. 106, p. 11).

Date	Place	Chairman	Secretary
1920	Chicago	Calvin H. Kauffman	
1921	Toronto	Arthur H. R. Buller	
1922	Cambridge	Cornelius L. Shear	
1923	Cincinnati	Wm. H. Weston, Jr.	
1924	Washington	Herbert S. Jackson	
1925	Kansas City	Edward M. Gilbert	Leva B. Walker
1926	Philadelphia	Frank L. Stevens	" " "
1927	Nashville	Wm. C. Coker	Carroll W. Dodge
1928	New York	Lee O. Overholts	" " "
1929	Des Moines	Carroll W. Dodge	George W. Martin
1930	Cleveland	Frank D. Kern	Alfred H. Povah
1931	New Orleans	Fred J. Seaver	Leon H. Leonian

At the annual meetings of the Section, officers were chosen for the succeeding year, the recommendations of a nominating committee usually being adopted unanimously. Ballot of the entire membership by mail was never attempted. Membership in the Section was itself of a somewhat indefinite category, all members of the Botanical Society with an expressed interest in fungi being listed as members of the Section. The membership grew from 100 in 1920 to 202 in 1930. In 1921 at the Toronto meeting the first joint session with the American Phytopathological Society was held. The joint session held in Cleveland in 1930 was the occasion of the presentation of the outstanding deBary memorial program.

MYCOLOGICAL SOCIETY OF AMERICA

The need for a mycological journal which would be representative of the broad interests of the members of the Mycological Section and which could be designated as its official organ finally led to discussion of the desirability of the transformation of the Section into a separate Mycological Society. Practical problems having to do with the financing of such a journal argued against the feasibility of its publication by the Section itself. Moreover, for other reasons the proposed establishment of a new Society was

attractive to many students. The journal Mycologia, founded in 1909 at the New York Botanical Garden in continuation of the Journal of Mycology, had come to be regarded as the national mycological publication. Interest in its enlargement and improvement and the desire to avoid the duplication of expense and effort which would result from the establishment of a new journal led to consideration of the possibility of adoption of Mycologia as the official organ of the proposed Society. The editor, F. J. Seaver, and Director E. D. Merrill of the New York Botanical Garden were approached and found to be receptive to the idea. Though Mycologia was in a sound financial condition it did not have the support of the entire body of American mycologists. Careful consideration indicated that all parties would be benefited by the adoption of the journal as the Society organ, and that the science of mycology in America would be served better by the enlargement and improvement of the journal already in existence than by the establishment of another. With this end in mind the following questionnaire was prepared and sent out by H. H. Whetzel, July 20, 1931, to all members of the Mycological Section:

"Discussion with workers in several institutions in the United States and Canada seems to indicate a wide-spread feeling among students of fungi that the interests of mycology can be promoted to better advantage in America through the organization of an independent mycological society to take the place of the Mycological Section of the Botanical Society of America and to be affiliated with the American Association for the Advancement of Science as are the other organizations, the American Phytopathological Society, the American Society of Plant Physiologists, etc. As a member of the Mycological Section we would like to know your feeling in the matter. Are you in favor of the formation of such a society?"

Replies to this questionnaire were received from 116 individuals. Of these, 91 voted in the affirmative and 25 in the negative. Nearly four out of five favored the proposal. Moreover, analysis of the ballots revealed that a goodly percentage of the negative votes had come from students of botany whose interests were not outstandingly mycological. The affirmative vote was enthusiastic and convincing. The list of those voting "yes" included most of

the active mycologists and practically all of the distinguished names identified with the science on this continent. It was the desire of all that dissension be avoided, and the unanimous conviction that the Mycological Section should disappear at the birth of the new Society. The recent unfortunate experience of the plant physiologists was in the minds of all, and the need for an overwhelming majority in favor of the establishment of the Society and the adoption of Mycologia was recognized. Meanwhile, the editor, F. J. Seaver, had sent a similar questionnaire to the approximately 150 personal subscribers to Mycologia, and had received practically unanimous approval of the plan. The 300 institutional subscribers to the journal were not approached.

The following December Professor Whetzel presented the result of the vote before the Mycological Section at the New Orleans meeting, and moved the formation of the new Society. Having been active in the development of the American Phytopathological Society in its early years, he entered enthusiastically on the new venture of helping found the Mycological Society of America. He, more than any other, had urged its formation, and to him is due the major credit for having taken the initial moves which led to its establishment at New Orleans. Doctor Seaver, numbered among those who looked with favor on the formation of the Society and on the adoption of Mycologia as its official organ, was that year Chairman of the Mycological Section. The Society came into being by official action of the Section, and though several negative voices were heard the final vote was essentially unanimous. An organizing committee of five members was then named, Wm. H. Weston, Jr., its chairman being designated as the first president of the Society, Herbert S. Jackson, Neil Stevens, and C. R. Orton being named as councilors, and your speaker being selected as secretary-treasurer (**12**, vol. 24, p. 515). It is only fair to record that only one of these five men was present at the New Orleans meeting, that they were nominated without their knowledge, and that none of them had been outstandingly an advocate of the formation of the Society. This committee, named to serve only for 1932, gave consideration during the year to the problems confronting the new organization, and sent out an invitation to charter membership which gained a most favorable re-

sponse. A note was published in Science inviting all persons interested in the fungi to affiliate with the Society, and a typewritten invitation was sent to more than one thousand individuals. All personal subscribers to Mycologia, all members of the Botanical Society of America listed as having a mycological interest, and all members of the American and Canadian Phytopathological Societies were thus given the privilege of being listed as charter members.

Although a relatively small number of individuals, assembled at New Orleans, had voted the Society into existence, the charter membership thus compiled embraces 279 names (**12**, vol. 26, p. 108). Tabulation of these names reveals that 149 individuals had been personal subscribers to Mycologia, 139 were members of the Botanical Society of America, 156 belonged to the American Phytopathological Society, 8 were affiliated only with the Canadian Phytopathological Society, while 44 names were new. The formation of the Mycological Society had been opposed by various members of the Botanical Society on the assumption that the older organization would be weakened by numerous resignations. It now appears that this fear was largely unfounded. A careful check of membership lists has recently revealed that of the 139 members of the Botanical Society who joined the Mycological Society in 1932 only 19 have been lost to the older organization. Only 7 of the 156 who came to us from the American Phytopathological Society have resigned from that society.

At the approach of the Atlantic City meeting of December, 1932, the organizing committee of the Mycological Society prepared a program, all charter members having been asked to take part. A business session was scheduled, and announcement was made of our intention to complete the organization of the Society and move the adoption of Mycologia. The committee met, December 27, and arranged materials for submission to the Society at its open business session the following day. A constitution and by-laws prepared by President Weston were edited and approved. Officers were nominated for 1933, and an editorial board for Mycologia was selected which named F. J. Seaver as its editor-in-chief (**12**, vol. 25, pp. 66, 152). The session the following day was outstandingly successful. Under the skillful and diplomatic

handling of President Weston (**12**, vol. 25, pp. 69–89, vol. 26, pp. 113–114), the meeting accomplished all necessary business without friction or misunderstanding, and the Society completed its organization with unanimous votes on practically all motions brought before it. There was a feeling akin to elation that the specter of a split in our ranks had failed utterly to materialize. Mycologia became the official organ of the Society on terms which had been arranged tentatively with the New York Botanical Garden. The meeting was well attended, forty mycological papers, representing a wide and varied interest, being presented on the program. The practice of holding joint sessions with Section G and with the American Phytopathological Society was begun.

The second annual meeting of our Society took place the following December in Boston with President C. L. Shear in the chair (**12**, vol. 26, p. 197). The third was held in December, 1934, at Pittsburgh, President H. S. Jackson presiding (**12**, vol. 27, p. 225). The fourth meeting last winter at St. Louis (**12**, vol. 28, p. 197) and the pleasing address of President B. O. Dodge are fresh in the minds of many of us. Summer forays have been held, in 1933 at the Highlands Museum and Biological Laboratory at Highlands, North Carolina (**12**, vol. 25, pp. 233, 330, 550, vol. 26, p. 195), in 1934 at the summer camp of Professor F. C. Stewart on Seventh Lake near Inlet, New York, in the southern Adirondack Mountains (**12**, vol. 26, pp. 277, 377, vol. 27, p. 323), in 1935 at Ithaca, New York, with headquarters in the Laboratories of the Department of Plant Pathology of Cornell University (**12**, vol. 27, p. 327, vol. 28, p. 98), and the past summer at Mountain Lake, Virginia, at the summer camp of the University of Virginia (**12**, vol. 28, p. 297). The present Atlantic City meeting marks the fourth anniversary of our first meeting here in 1932 and the fifth of the establishment of the Society at New Orleans. Our membership has now reached a figure slightly above 350. The Society is in a sound condition financially and has every reason to expect a long and useful life. With an increasing membership, with an enlarging and improving journal, with a fine spirit of friendship and coöperation existing throughout our ranks we face the future with optimism. It is our expectation that the Mycological Society of America will increase in size and usefulness, and

our hope that an enlarging Mycologia will publish material of such uniform excellence that it will stand preëminent among the mycological journals of the world.

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NOTES ON CHINESE CERCOSPORAE

CHARLES CHUPP AND DAVID H. LINDER[1]

(WITH 1 FIGURE)

During the course of a coöperative undertaking of the University of Nanking and the Farlow Herbarium of Harvard, the latter institution has received a number of parasitic fungi. Among these are quite a few representatives of the genus *Cercospora,* all of which were collected by Mr. S. Y. Cheo whose numbers are cited below.

These collections are of interest since a large proportion of them represent the *Passalora* or *Cladosporium* type of fructification in which the fungi at first form no definite spots, but rather produce effuse velvety layers over parts of the leaf surface. In certain of the species, the conidiophores arise in two manners: from the repent vegetative mycelium as erect or ascending side-branches, or else either singly or in clusters from the stomata of the host. However, although the former type seems to be characterized by more elongate conidiophores, nevertheless they essentially are morphologically identical, as is also true of the conidia.

In the list which follows, the species are arranged alphabetically and not according to any concept of phylogenetic relationships of the various hosts.

1. CERCOSPORA AGERATOIDES Ellis & Ev.

On *Eupatorium* sp., Lao Hu Tung, Ch'ing Yang Hsien, Anhwei Prov., Oct. 12, 1932, No. *1199;* Shiang Lu Shib, Ch'ing Yang Hsien, Anhwei Prov., Oct. 9, 1932, No. *1156;* Ta Tseh Shan, Yung Hsien, Kwangsi Prov., Sept. 1, 1933, No. *2672.*

2. CERCOSPORA ARALIAE P. Henn.

On *Aralia* spp., Liang Feng Yah, Tsunyi Hsien, Kweichow Prov., on *A. dasyphylla,* July 18, 1931, No. *93;* Fan Ching Shan,

[1] Contribution from the Department of Plant Pathology, Cornell University, and from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, No. *147.*

Chiang K'ou Hsien, Kweichow Prov., on *Aralia dasyphylla,* Sept. 6, 1931, No. *367;* Hsiu Feng Ssu, Hsing Tsu Hsien, Kiangsi Prov., Sept. 16, 1932, No. *944;* Kuan Yin Tung, Ch'ing Yang Hsien, Anhwei Prov., Oct. 13, 1932, No. *1216;* Ta Tseh Shan, Yung Hsien, Kwangsi Prov., Aug. 10, 1933, No. *2425* and Aug. 20, 1933, No. *2539.*

3. **Cercospora Broussonetiae** sp. nov. (FIG. A)

Maculae primum indefinitae, fungus stratum amphigenum effusum, 2–4 mm. latum, atro-olivaceum formans, superne paucius; stromatis parenchymatis sphaericis atro-fuscis vel fere atris, 30–70 μ diametro, hyphas conidiferas dense fasciculatas gerentibus; conidiophoris conspicuiter septatis, nonnumquam ad septa constrictis, non geniculatis tamen curvatis vel flexuosis, raro ramosis, olivaceo-fuscis, 4–6 × 50–150 μ; conidiis cylindraceis vix obclavatis, olivaceo-brunneo vel fuligineo-brunneis, rectis vel nonnihil curvatis, ad bases obconicis truncatisque, ad apices rotundatis, 4–5.5 × 40–90 μ, pluriseptatis, frequente arcte septatis.

Hab. in foliis *Broussonetiae* sp.

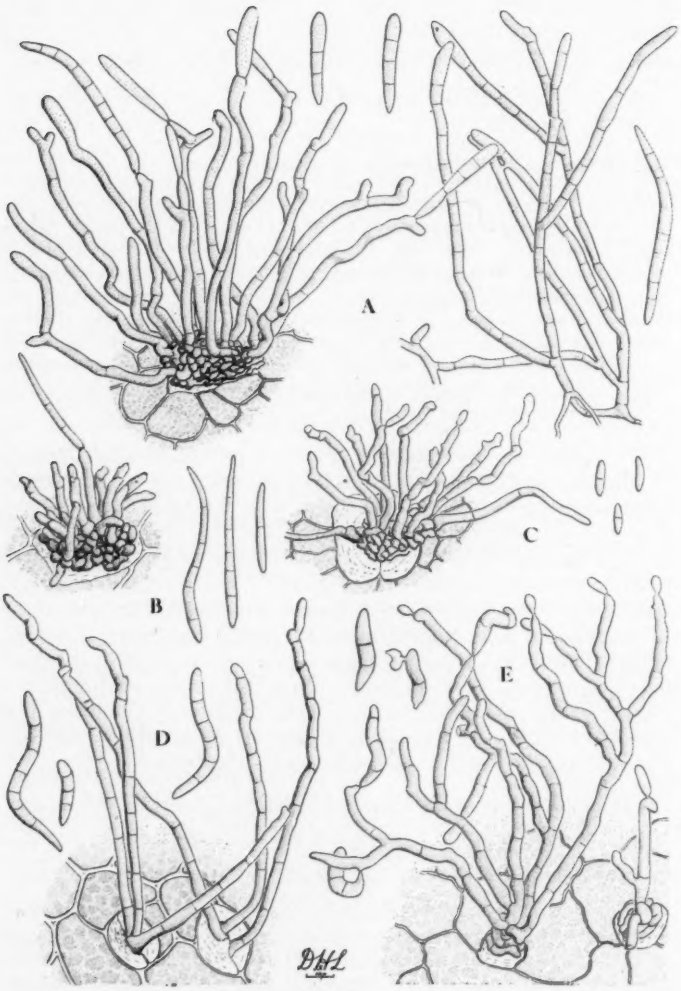
No definite leaf-spot, at least at first; fruiting in amphigenous, effuse, dark olivaceous layers, 2–4 mm. in extent, the colonies much more sparingly formed on the upper than the lower surface; the stromata dark brown to almost black, globular, 30–70 μ in diameter, giving rise to dense fascicles of conidiophores; conidiophores plainly septate, occasionally the septa are very close together (4 μ), sometimes constricted at the septa, not geniculate although sometimes bent and not uniform in width, rarely branched, olivaceous brown, 4–6 × 50–150 μ, spore scars not conspicuous; conidia more nearly cylindrical than obclavate, olivaceous brown or fuligenous brown, plainly many-septate, the septa often very close together (2.5 μ), straight or only slightly curved, the base conical and truncate, the tip bluntly rounded, 4–5.5 × 40–90 μ.

On leaves of *Broussonetia* sp., Ta Tseh Tsuen, Yung Hsien, Kwangsi Prov., Oct. 17, 1933, No. *2900,* **Type.**

4. **Cercospora Cheonis** sp. nov. (FIG. C)

Maculae orbiculares, 1–5 (plerumque 2–3) mm. diametro marginibus prominente elevatis, primum atrae deinde caesiae vel alutaceae, denique maculae excidunt; stromatis hypophyllis, sphaericis vel hemisphaericis, atro-brunneis vel atris, 25–50 μ diametro, hyphas conidiferas dense fasciculatas gerentibus; conidiophoris fuligeneo-brunneis, multiseptatis, leniter geniculatis, raro ramosis, 2–3.5 × 40–100 μ; conidiis cylindraceis, rectis vel raro subrectis, plerumque 1-septatis, fuliginea-oblivaceis, 3–4 × 15–30 μ, extremis rotundatis.

Hab. in foliis *Ilecis* sp.



FIGS. A, *Cercospora Broussonetiae;* B, *C. Vanieraе;* C, *C. Cheonis;* D, *C. cylindrata;* E, *C. Leguminum.*

Spots circular, 1–5 (mostly 2–3) mm. in diameter, with prominently raised line as border, the spots at first are apparently tar black but then turn tan to gray, later the leaf-spots may drop out leaving a shot-hole effect; stromata hypophyllous, globular, dark brown to almost black, 25–50 μ in diameter; the fascicles dense; the conidiophores 2–3.5 $\times$ 40–100 μ, fairly dark fuligenous brown, multiseptate, slightly geniculate, rarely branched and with spore scars seldom visible; conidia cylindrical, straight or nearly so, mostly 1-septate, fuligenous olivaceous, with bluntly rounded ends, 3–4 $\times$ 15–30 μ.

On leaves of *Ilex Wilsonii* Loes., Huang Yen Ssu, Hsing Tzu Hsien, Kiangsi Prov., Sept. 13, 1932, No. *922,* **Type.**

5. **Cercospora cylindrata** sp. nov. (FIG. D)

Maculae indefinitae; fungus hypophyllus, stratum atro-olivaceum vel atrum coactatum formans; stromata absunt; conidiophoris (90)–150–290 $\times$ 4.5–6.0 μ, non fasciculatis vel 1–5 ex stomatibus hospitis exsurgentibus, frequenter singillatim ab hyphis sterilibus ramosis, fuligineo-brunneis, 4–5 μ diametro, repentibus oriundis; condidiis fuligeneo-brunneis, cylindraceis, curvatis vel spiraliter undulatis, ad apices rotundatis, ad bases obconicis, 4–6.5 $\times$ 25–75 μ, 3-septatis, septis conspicuis.

Hab. in foliis *Dioscoreae* sp.

No definite leaf spots; fruiting in a dark olivaceous to almost perfectly black, felty layer on the lower surface of the leaf; conidiophores not in fascicles but consisting of branches arising from procumbent, septate, branched mycelial threads that are 4–5 μ in diameter, or else the fuligenous brown conidiophores, 4.5–6 $\times$ (90)–150–290 μ, arise singly or in loose clusters of from 2–5; conidia distinctly cylindrical, fuligenous brown, variously curved or undulate, the apex bluntly rounded, the base sharply obconical, 4–6.5 $\times$ 25–75 μ, the septa quite evident and 3–5 in number.

On leaves of *Dioscorea* sp., Yung Hsien, Ta Tseh Tsuen, Kwangsi Prov., Aug. 18, 1933, No. *2515,* **Type.**

C. cylindrata resembles *C. alpiniae* in some respects, but the latter produces noticeably darker colored conidiophores and conidia, and the conidiophores are single, unbranched stalks. It differs from all other named species on the Iridales, Liliales, or Alismatales, in having wide, distinctly cylindrical conidia on procumbent branched threads.

6. CERCOSPORA FERRUGINEA Fuckel.

On *Artemisia* sp., Han Young Feng, Lu Shan, Kiangsi Prov., Sept. 24, 1931, No. *1053*.

This species has previously been reported from Cina.

7. CERCOSPORA ITEODAPHNES Thüm.

On *Actinidia callosa* Lindl., vel rel., Ta Ho Yen, Chiang K'ou Hsien, Kweichow Prov., Sept. 21, 1931, No. *570*.

This species was first described from Ceylon.

8. **Cercospora Leguminum** sp. nov. (FIG. E)

Maculae primum indefinitae deinde superficie supera brunescens dum in superficie infera fungus stratum densum, effusum, atro-olivaceum vel subnigrum effecit; stromata exilia vel absunt; conidiophoris non definite fasciculatis vel fasciculatis, procumbentis vel erectis flexuosisque, ramosis, conspicuiter septatis, saepe ad septa constrictis, non geniculatis, curvis autem vel superne breve ramosis, olivaceo-brunneis, 4–6.5 μ diametro; conidiis rare rectis, plerumque curvatis, nonnihil undulatis vel uncinatis, cylindraceis, ad bases elongato-obconicis, ad apices abrupte rotundatis, dilute olivaceo-brunneis, 4.5–7.5 $\times$ 15–50 μ, septis conspicuis, 1–4.

Hab. in foliis *Crotaleriae?* (Leguminosae).

No definite leaf spot formed, at least at first, but later the upper part of the leaf turns brown while on the corresponding lower surface is formed a heavy, effuse, fruiting layer, dark olivaceous to almost black in color; stroma poorly developed or lacking; conidiophores not in definite fascicles, procumbent to erect, branched, plainly septate, sometimes constricted at the septa, frequently not uniform in diameter, not geniculate but may be bent in various ways or have short branches near the tip, olivaceous brown, 4–6.5 μ wide and of indeterminate length; conidia rarely straight, mostly irregularly curved, hook-shaped, S-shaped, and sometimes almost a complete circle, cylindrical, elongate-obconical at the base and bluntly rounded at the apex, 4.5–7.5 $\times$ 15–50 μ, pale olivaceous brown, mostly 1–4-septate, the septa conspicuous brown.

On leaves of *Crotalaria?* vel rel., Lo Ch'en, Kwangsi Prov., Oct. 1, 1933, No. *2873*, **Type.**

9. CERCOSPORA MELIAE Ellis & Ev.

On *Melia* sp., Kuan Ying Chioo, Lu Shan, Kiangsi Prov., Sept. 25, 1932, No. *1064*.

From a study of the type materials, it seems that *C. Meliae* Ellis & Ev. 1887, *C. leucosticta* Ellis & Ev. 1888, and *C. subsessilis* Sydow 1913, have similar white spots, brown stromata, mostly short conidiophores which bear obclavate subhyaline conidia with conical or subconical bases. *C. meliicola* Speg. has pale olivaceous stromata, fairly long conidiophores, and very narrow, thread-like, hyaline conidia of which the bases are truncate. *C. congoensis* Sydow is *Cladosporium*-like, does not produce stromata, and bears conidia that are 7–9 μ wide.

10. CERCOSPORA MIURAE Sydow.

On *Cynanchum* sp., Lao Hu Tung, Ch'ing Yang Hsien, Anhwei Prov., Oct. 12, 1932, No. *1198*.

First described from Rebun Island.

11. CERCOSPORA PACHYDERMA Sydow.

On *Dioscorea* spp., Ta Ho Yen, Chiang K-ou Hsien, Kweichow Prov., Sept. 14, 1931, on *D. pentaphylla*, No. *479;* Ta Tseh Shan, Yung Hsien, Kwangsi Prov., Aug. 5, 1933, No. *2346*.

12. CERCOSPORA PERSONATA (Berk. & Curt.) Ellis.

On *Arachis*, Hsing Tsu Hsien, Lu Shan, Kiangsi Prov., Sept. 17, 1932, No. *958;* Shiang Lu Shih, Ch'ing Yang Hsien, Anhwei Prov., Oct. 13, 1932, No. *1234;* Ta Tseh Shan, Yung Hsien, Kwangsi Prov., Aug. 16, 1933, No. *2492*.

13. CERCOSPORA POLYGONORUM Cooke.

On *Polygonum aviculare* L. vel rel., Ta Ho Yen, Chiang K'ou Hsien, Kweichow Prov., Oct. 7, 1931, No. *663*.

This species, as *C. hydropiperis*, has been reported from many countries.

14. CERCOSPORA SNELLIANA Reichert.

On *Morus* sp., Syn.: *C. Mori* Mar. & Stey.

Liang Feng Yah, Tsunyi Hsien, Kweichow Prov., Aug. 2, 1931, No. *209*.

This species was first described from Egypt, and later as *C. Mori* from the Belgian Congo.

15. **Cercospora Vanierae** sp. nov. (FIG. B)

Maculae primum indefinitae, fungus stratum hypophyllum effusum, olivaceum formans, interdum in superficie superficiore pustulas olivaceas, myceliorum apressorum, ramosorum conidia gerentium constatas, 0.5–2 mm. diametro formans, in superficie inferiore conidiophoris semi-fasciculatis in stromatibus, ramosis, conspicuiter septatis, interdum ad septa constrictis, dilute olivaceo-brunneis, nonnumquam geniculatis, 4–6 × 50–110 μ; conidiis conspicuiter obclavatis, dilute olivaceis, rectis vel curvulis, ad apices acutis, ad bases longe obconicis truncatisque, 3.5–5.5 × 50–100 μ, multiseptatis frequenterque 5 μ separatis.

Hab. in foliis *Vanierae tricuspidatae* (Bur.) Merr.

No definite leaf spots, at least at first; fruiting in hypophyllous, effuse olivaceous layers, ranging in extent from 0.5 mm. to fairly large parts of the leaf surface; sometimes on the upper surface are small dark olivaceous pustules, 0.5–2 mm. in extent, composed of appressed, procumbent, branched threads on which the conidia are borne. On the lower leaf surface the conidiophores are in fascicles or semi-fascicles arising from stromata, branched, plainly septate, sometimes constricted at the septa, pale olivaceous brown, sometimes plainly geniculate, spore scars not present, 4–6 × 50–110 μ; conidia plainly obclavate, pale olivaceous, straight to slightly curved, tip rounded acute to sub-acute, base long, obconically truncate, septa evident, many, and in some cases as close together as 5 μ, 3.5–5.5 × 50–100 μ.

On leaves of *Vaniera tricuspidata* (Bur.) Merr., Sze Nan Hsien, Kweichow Prov., Aug. 27, 1931, No. *338*, **Type.**

Type specimens of the new species above described, have been deposited in the Farlow Herbarium, Harvard University, and in the Herbarium of the Department of Plant Pathology, Cornell University.

CORNELL UNIVERSITY
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EXPLANATION OF FIGURES

Fig. A. *Cercospora Broussonetiae.* The figure on the right shows the conidiophores arising from the repent vegetative mycelium. On the left, the conidiophores are shown arising from the stroma that is formed over the stoma of the host. In both figures are to be seen the rather characteristic swellings of the terminal cells of the conidiophores. **Fig. B.** *Cercospora Vanierae.* On the left is shown a dense fascicle of conidiophores which arise from the stroma, while on the right are three conidia that illustrate in part the variation in size and shape. **Fig. C.** *Cercospora*

Cheonis. Three conidia and the fascicle of conidiophores are here shown. The conidiophores are characterized by the subgeniculate apical cells and by occasional deep constrictions at the septa. Not infrequently, one or more of the conidiophores bend over and serve in much the same fashion as stolons. **Fig. D.** *Cercospora cylindrata.* The conidiophores are shown arising from the stoma of the host without the formation of any stromatic base. The three conidia illustrate the variation to be found in this species. **Fig. E.** *Cercospora Leguminum.* The branched, undulate conidiophores of this species arise from a poorly developed stromatic base that consists of a few coiled and interwoven hyphae. Not infrequently the conidia are not only spirally undulate, but may also be horse-shoe shaped, and occasionally the spores proliferate to form a secondary spore that is smaller and of a lighter color.

DIPODASCUS UNINUCLEATUS [1]

ROSEMARY BIGGS [2]

(WITH 50 FIGURES)

The fungus to be described in the following pages was originally obtained in culture from a dead pupa of *Drosophila melanogaster*. The most remarkable character of the agar colonies is the production of multispored asci which bear a strong resemblance to those described for *Dipodascus albidus* Lag. A detailed study of the development of these structures has indicated that, although the organism is indeed closely related to that much discussed species, it presents a number of interesting differences.

The life history of *D. albidus* has been studied in detail by Lagerheim (**8**), Juel (**7**) and Dangeard (**3**). The species has always occupied a somewhat isolated position among the fungi. The coenocytic cell structure and the development of multispored asci following the fusion of two simple multinucleate gametangia have been thought to indicate affinities with the Phycomycetes. On the other hand a relationship with the Ascomycetes is suggested by the method of spore formation and the absence of a resting zygote. The apparently transitional nature of this fungus has led to the rather general opinion that it represents an intermediate link in the evolution of the Ascomycetes from the Phycomycetes (**1, 2, 4, 5, 9, 10** and **11**). It is on account of the theoretical significance assigned to *D. albidus* that the discovery of another species in this genus is of especial interest.

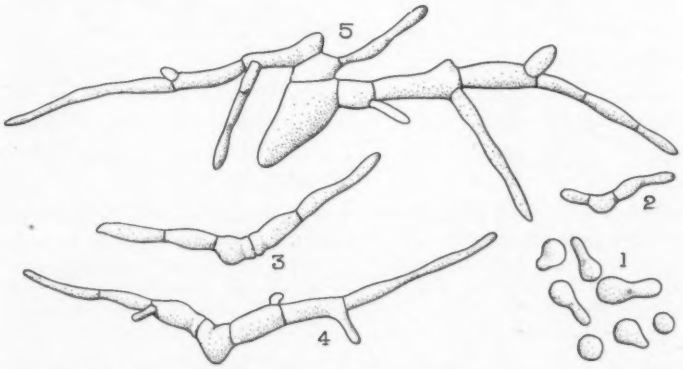
Dipodascus uninucleatus was grown on a number of media including a variety of liquid sugars, potato dextrose agar, a one per cent lactose agar and a one and two per cent malt extract agar. The latter medium was found to be the most satisfactory. The growth in liquid media was in general poor.

[1] Contributions from the Department of Botany, University of Toronto.

[2] This study has been made under the direction of Professor H. S. Jackson to whom I wish to express my appreciation for continued interest and helpful suggestions.

In addition to the original gross cultures a number of monospore cultures were obtained by pouring dilution plates from ascospores. These did not differ from the polysporous cultures and asci were developed in abundance indicating that the fungus is homothallic.

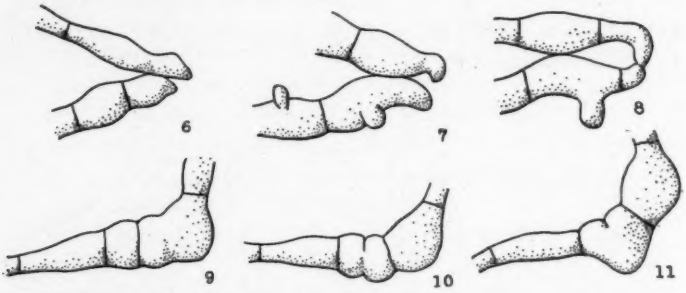
A study of the development of the organism was made by continuous observation of developing threads derived from germinating ascospores growing in a two per cent malt extract solution in van Tieghem cells. In such preparations the whole life cycle can be followed in a single filament from the germination of the spores to the maturation of the asci.



FIGS. 1–5. Stages in the germination of growth of the ascospores. 1, germinating spores from a thirty-six hour culture; 2–5, stages in the growth of a single filament; 2, after forty-eight hours; 3, after sixty-two hours; 4, after seventy-one hours; 5, after eighty-five hours. All figures × 710.

During the first twenty-four to thirty-six hours after transfer to a hanging drop the minute ellipsoid spores, 0.6–1 × 2–2.5 μ, swell considerably and assume a spherical form, 3–4 μ in diameter. A short germ-tube is then put out from one side of the expanded spore (FIG. 1) and during the next two or three days a short filament of four or five cells is produced (FIG. 2, 3). At this stage ascus formation begins (FIG. 3–5). Vegetative growth continues and the hyphae become more or less extensively branched (FIG. 4, 5). This organism differs from *D. albidus* in the complete absence of asexual reproduction.

The first sign of ascus development is the formation of two small contiguous cells usually in the central region of the filament (FIG. 3, 9). Almost before these cells are fully delimited the septum between them begins to disappear and after about two hours fusion is complete (FIG. 9, 10). The two uniting cells do not invariably arise from the same filament but, especially in crowded culture, fusion may occasionally take place between terminal cells of different filaments (FIG. 6–8).



FIGS. 6–11. Stages in cell fusion. 6–8, consecutive stages in the fusion of terminal cells of different filaments; 6, after forty-eight hours growth; 7, after fifty hours growth; 8, after sixty-seven hours growth; 9–11, consecutive stages in the fusion of intercalary cells in the same filament; 9, after forty-eight hours growth; 10, after fifty hours growth; 11, after fifty-three hours growth. All figures × 1250.

CYTOLOGICAL INVESTIGATIONS

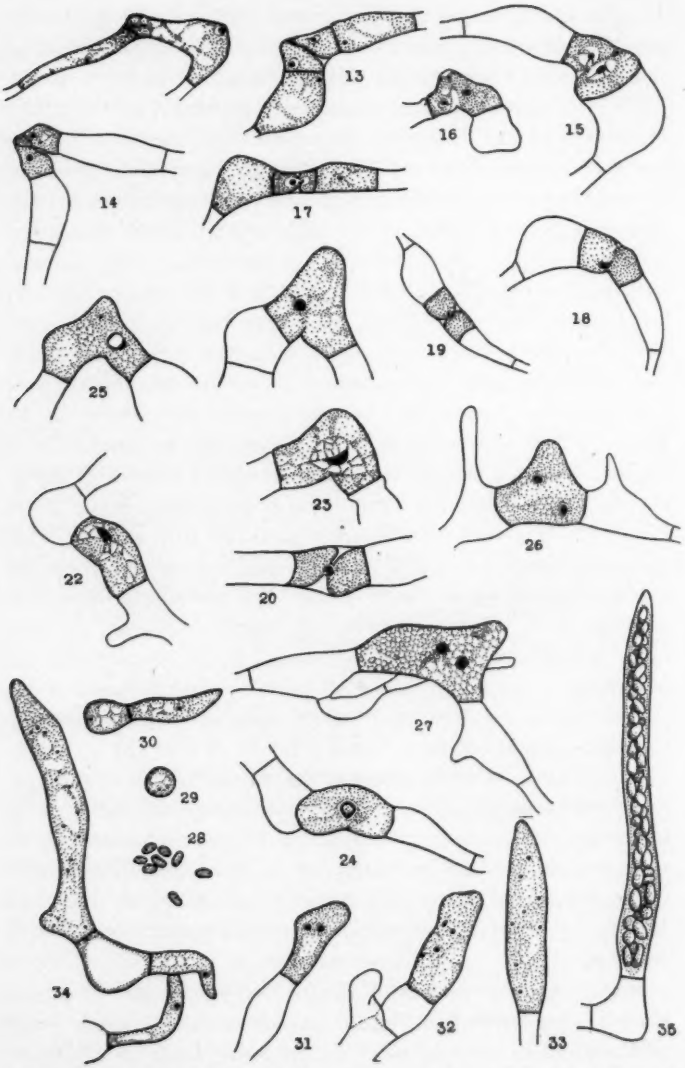
A cytological study of ascus development was made with germinating ascospores grown in van Tieghem cells. The cultures were watched until the required stage was reached when a drop of Bouin's fluid was added. The sporelings were attached to the cover glass by allowing the cultures to dry down in the fixing solution. The preparations were then thoroughly washed and stained by the iron alum haematoxylin method. It is recognized that this technique is by no means delicate, however it was unnecessary for the present purposes to study details of nuclear division and microtome sections proved unsatisfactory owing to the difficulty in obtaining whole asci in any one section.

The ascospores and all the cells of the hyphae are uninucleate. This is an important distinction from *Dipodascus albidus* in which

the vegetative cells are consistently multinucleate. In the formation of the copulating cells an accumulation of cytoplasm occurs on either side of a transverse septum, whereupon the nuclei in the adjoining cells divide and two minute cells are cut off (FIG. 12, 13). These cells are not always of exactly the same size (FIG. 15) nor are they invariably cut off at exactly the same time (FIG. 9). However no consistent differences such as would lead to the distinction between male and female gametangia could be recognized. The next stage in development is the dissolution of the dividing wall, this does not occur evenly over the whole surface but may begin at the centre (FIG. 15, 17, 19, 20) or towards one side (FIG. 16). Nuclear fusion usually occurs at an early stage in cell fusion and often takes place in the narrow passage joining the two cells (FIG. 19–20). The fusion nucleus enlarges and finally divides (FIG. 21–27). The further development of the ascus is very simple. The cell elongates considerably and a number of simultaneous nuclear divisions occur. The number and position of the nuclei can be traced with accuracy until the fifth division when thirty-two nuclei are present (FIG. 36–41). After this the nuclei become so small and so numerous that they cannot be counted with accuracy, it is however evident that several additional divisions occur before the spores are delimited. From the irregular arrangement of the nuclei during all stages of development it is apparent that no set orientation of the spindles occurs in the first three divisions as has been reported for *D. albidus* (**3**).

It is scarcely possible to study the details of the cytology of spore formation owing to the very minute size of the nuclei at this stage. The asci developed in van Tieghem cells never attain to more than half the maximum size of those developed on agar. On this account it was found most satisfactory to study the morphology of spore formation in crushed preparations of agar colonies.

An examination of nearly mature asci shows that the spores are often not formed simultaneously throughout the whole length of the ascus but are delimited progressively from the tip downwards. Mature spores may be present at the tip of an ascus in which the lower half is filled with undifferentiated protoplasm and free nuclei (FIG. 42). In early stages of delimitation the spores



FIGS. 12–35. 12–27, early stages in ascus formation; 12–17, formation and fusion of copulating cells; 18–20, stages in nuclear fusion; 21–25, enlargement and division of the fusion nucleus; 26–27, binucleate asci; 28–30, ascospores and stages in germination; 31–35, stages in parthenogenetic development of asci. All figures × 1550.

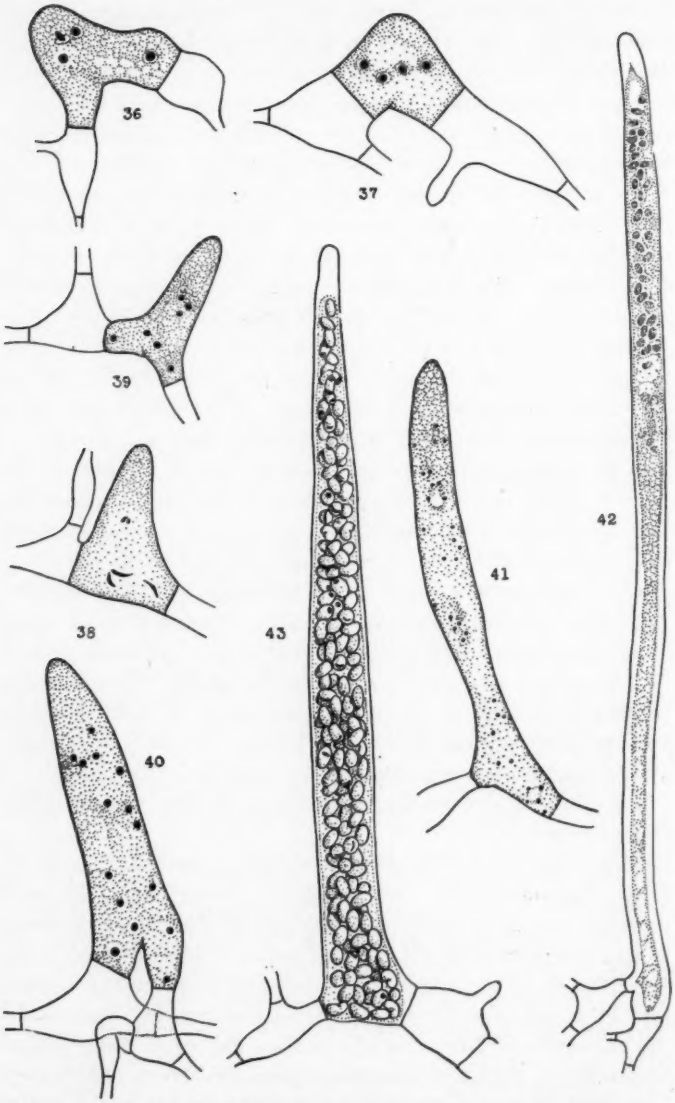
are seen to be embedded in epiplasm indicating their origin by free cell formation. This extraneous cytoplasm is absorbed during the maturation of the spores and finally no trace of it remains. There is some evidence from cytological preparations that the nuclei may be eccentrically placed in the young spores as was recorded by Dangeard (3) for *D. albidus* (FIG. 43).

The method of liberation of spores is of interest. Just before their formation, the ascus wall begins to swell. This swelling is limited at first to the extreme tip and to the basal region (FIG. 42). As development progresses the tip of the ascus gelatinizes leaving a free opening for the liberation of the spores. The swelling of the vertical wall continues progressively from the base towards the tip of the ascus forcing the spores out of the tip where they accumulate as a sticky ball. These finally roll down the sides of the protruding asci and develop into new threads.

From these observations the following general picture of the growth of the fungus may be obtained. The spores germinate, and develop into filaments of limited growth. Asci are formed and spores are liberated all in the course of four or five days. These spores in turn grow and produce asci. Thus successive generations pile up on the original colony all the hyphae of which meantime extend slowly by vegetative growth. The asci produced by later generations become progressively smaller and less abundant as the availability of the food decreases. Finally very few asci are produced and the colony changes very little in size and general appearance during long periods of time.

Two theoretically interesting variations on this general theme might be noted.

Occasionally asci may develop without a previous fusion of cells. This conclusion is indicated by the production of very small terminal asci in crowded cultures. In cytological preparations from such cultures there is no suggestion of cell fusion in the formation of these minute asci nor was an enlarged fusion nucleus ever observed (FIG. 31–35). A second noteworthy variation is the production of very small intercalary asci when the organism is grown on a one per cent lactose agar. On this medium a very poor growth takes place and a complete range of variation in ascus size occurs from more or less normal elongate asci to undiffer-



FIGS. 36–43. Later stages in ascus formation. 36–41, four to thirty-two nucleate stages, × 1550; 42, formation of spores, from a lactophenol preparation of an agar culture, × 775; 43, mature ascus, × 1550.

entiated hyphal cells which may contain less than eight spores (FIG. 44–50). In some cases there is evidence of a previous fusion of cells in the formation of these asci (FIG. 50), but it seems probable that the smaller ones may be developed parthenogenetically.

TECHNICAL DESCRIPTION

Dipodascus uninucleatus sp. nov.

Hyphiis ramosis, septatis, ad septa constrictis, sine conidiis, 2.4–2.6 μ crassis; cellis uninucleatis; ascis longe cylindraceis, sursum attenuatis, multisporis, 7–8 × 90–180 μ; ascosporis ellipsoideis, 0.5–1.0 × 2.0–2.8 μ.

Colony circular pulvinate; edge wavy, surface glistening, gyrosely wrinkled; consistency butyrous; color opaque; coloration of the medium none. Hyphae branched, septate, constricted at the cross walls, 2.4–2.6 μ in diameter in young cultures, in old cultures very irregular. Asexual reproduction none. Cells consistently uninucleate. Asci elongate, multisporous, diameter 7–8 μ tapering to 4–5 μ at the tip, length extremely variable, in young cultures 90–180 μ. Spores minute ellipsoid 0.5–1.0 × 2.0–2.8 μ, liberated from the tip of the ascus by gradual extrusion.

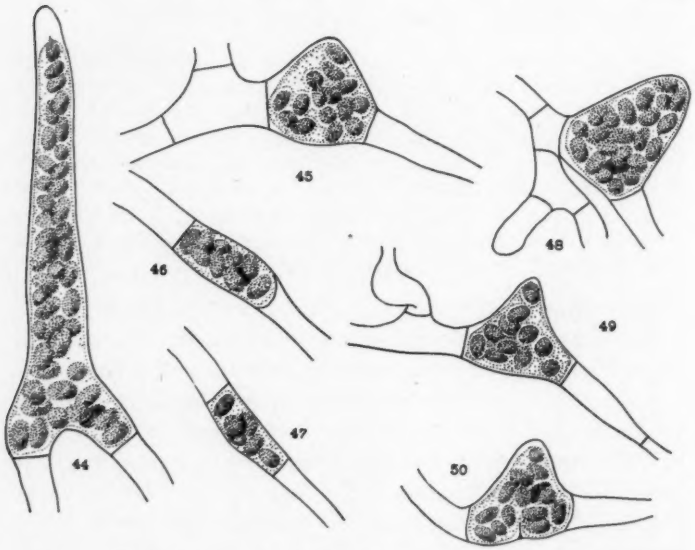
The cultures of *Drosophila melanogaster* from which *D. uninucleatus* was obtained were maintained as genetics class material in the Department of Botany in the University of Toronto.

Slides of this organism have been deposited in the Herbaria of the Universities of Toronto, Harvard and Cornell. Cultures have been deposited with the mycological laboratories at the above Universities and in the American Type Culture Collection at Chicago, Illinois and in the Centraalbureau voor Schimmelcultures at Baarn, Holland.

DISCUSSION

Dipodascus uninucleatus shows relationship to *Dipodascus albidus* in the structure of the mature asci and in the method of formation and liberation of the spores. On the other hand the limited, somewhat yeast-like growth, the uninucleate cells and the small asci developed on lactose agar are reminiscent of the Endomycetaceae. Recent investigations of *Ascoidea rubescens* are of interest in this connection. In this organism the asci develop from multinucleate hyphal tips either with (Varitchak **9**) or without

(Walker **11**) a fusion of nuclei. The mature asci are multispored and the spores have the peculiar hat shape characteristic of certain species of *Endomyces* and Saccharomycetaceae. *Ascoidea rubescens* shows relationship to *Dipodascus albidus* in the development of the asci from multinucleate cells and also shows affinities with Saccharomycetaceae in the characteristic shape of the spores. The present study and the recent work on *A. rubescens* indicates that *Dipodascus albidus* no longer occupies the very isolated position usually assigned to it but is connected to the



FIGS. 44–50. Abnormally small asci developed on a one per cent lactose agar. 44, ascus of reduced size retaining the normal elongate form; 45–49, various greatly reduced asci; 50, an ascus showing indications of a previous fusion of cells. All figures × 1550.

Endomycetaceae through both *D. uninucleatus* and *A. rubescens*. It might even be justified to question the necessity for placing this genus in a special family.

In the light of this evidence the apparently phycomycetous characters of *D. albidus* may have less significance than has been given them. With regard to the coenocytic cell structure, this

character shows considerable variation in Endomycetaceae and even within the genus *Dipodascus*. Further a comparison of ascus development in *D. uninucleatus* and *D. albidus* shows that the presence of supernumerary nuclei within the ascus of the latter is a direct consequence of the multinucleate cell structure. Finally multisporous varieties occur in many orders of the higher Ascomycetes and there would seem to be little justification for considering this character to be of greater significance in one group than in another.

A critical review of the general characters of the fungi included in the Hemiascomycetes of Varitchak (**9**) and in the Endomycetales strongly suggests that they may be a collection of reduced forms. Most of the genera occupy special habitats. All the genera so far reported are homothallic and on genetical grounds it would appear that heterothallism is necessary for progressive evolution. The marked tendency to parthenogenesis in all the genera could well be correlated with a loss in the significance of the sexual process through homothallism. Finally all these fungi are more or less related to the Saccharomycetaceae (**6**) which are generally recognized to be reduced.

The hypotheses involving the origin of the Ascomycetes from the Phycomycetes through the Endomycetales all presuppose that this order has been derived from an ancient transitional group combining the characters of both Ascomycetes and Phycomycetes. This assumption is at present with little foundation and the equally possible method of origin from higher forms by reduction should at least be considered. Until further evidence is available it would seem best to view the problem of the phylogeny of the simpler Ascomycetes with an open mind in order that the accumulating evidence may be correctly assessed.

SUMMARY

Dipodascus uninucleatus was obtained in culture from a dead pupa of *Drosophila melanogaster*. The vegetative growth is yeast-like and no asexual reproduction occurs. The fungus is homothallic. The cells are consistently uninucleate. The asci arise from the fusion of two undifferentiated uninucleate cells and develop after nuclear fusion. The mature asci are elongate, multi-

spored and bear a marked resemblance to those described for *Dipodascus albidus* Lag.

D. uninucleatus possesses characters which suggest a closer relationship of the genus *Dipodascus* with the Endomycetaceae than has hitherto been recognized.

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NEW AND UNUSUAL AGARICS FROM THE WESTERN UNITED STATES [1]

ALEXANDER H. SMITH

(WITH 3 FIGURES)

While studying the species of *Mycena* (**14**) occurring in Washington, Oregon and California during the fall of 1935 many agarics in other genera were also collected. Fifteen of the more outstanding species are critically discussed or described in this paper. Four new species are described, and three, *Clitocybe albiformis* Murrill, *Psilocybe ochraeceps* Kauffman, and *Naucoria elatior* (Peck) Sacc. are reduced to synonymy. Particular attention was given to species of *Naucoria* in the section segregated as the genus *Phaeocollybia* by Heim (**5**). Five species in this group, including two that are new, are critically compared.

The collection numbers and photographs are the writer's unless otherwise stated. All the collections are deposited in the herbarium of the University of Michigan.

CLITOCYBE ALBISSIMA (Peck) Sacc.

Pileus 6.5–11 cm. broad, broadly convex to nearly plane, seldom slightly umbonate, the margin at first inrolled and under a lens appearing cottony pubescent, surface dry, dull and unpolished, usually ribbed near the whitish margin, the disk cream colored or with a faint tinge of tan; flesh thick and firm, white, dry, odor faintly fragrant, taste mild; lamellae pure white, crowded, narrow, many forking once near the stipe, decurrent by long lines which occasionally anastomose, not readily separable; stipe 8–15 (20) cm. × 1.5–2 (3) cm., equal or clavate, white, dry, pruinose scurfy to pubescent above or rather evenly covered by minute innate squamules, base often with a white cottony mycelium, solid, flesh white; spores 7–8 × 4–5 μ, ellipsoid, echinulate, dark violet with iodine in chloral hydrate; basidia four-spored; cystidia not differentiated; pileus trama homogeneous, cuticle of a compact layer of narrow subparallel hyphae.

[1] Papers from the Department of Botany and the Herbarium of the University of Michigan, no. 588.

Gregarious around redwood stumps, Trinidad, Calif., Nov. 27, 1935, H. E. Parks and A. H. Smith (*3626*). This species is close to *Clitocybe piceina* Peck, but is readily distinguished by the mild taste and pure white gills. The spores of both species stain dark blue in iodine, are echinulate and measure 7–8 × 4–5 μ. The western form is larger than that usually considered typical, and in certain respects it approaches *Clitocybe gigantea* Fries. *Clitocybe albiformis* Murrill is only a large form of *C. albissima.* The spores of Murrill's type are minutely echinulate, stain dark violet in iodine in chloral hydrate, and measure 6–7 × 4–4.5 μ.

COLLYBIA UMBONATA Peck.

Pileus 4–8 (10) cm. broad, obtusely conic, becoming expanded and conspicuously umbonate, faintly fibrillose-pruinose under a lens, soon glabrous, "chestnut-brown"[2] on the disk, "hazel" toward the margin, at times "russet" or "bay" on the umbo and "buckthorn brown" near the margin, hygrophanous, fading to "warm buff" near the margin, the disk remaining somewhat darker, surface smooth or radially rugulose; flesh thick under the umbo, tapering gradually to the margin, buffy tan in color, pliant and very cartilaginous, odor and taste not distinctive; lamellae close, narrowly and deeply adnexed, broad, tapering evenly to the margin, pale buff ("warm buff"), becoming slightly darker, edge slightly uneven, at times slowly changing to brownish when bruised; stipe 8–10 (12) cm. × 6–10 mm., strict, glabrous and equal above a long pseudorhiza, smooth or at times twisted and striate due to the longitudinal splitting of the cuticle, concolorous with pileus or more yellowish brown, hollow, very cartilaginous; spores 5–6 × 3 μ, smooth, hyaline, ellipsoid; basidia four-spored; cystidia very abundant on sides and edges of lamellae, 57–86 × 8–15 μ, fusoid-ventricose, smooth; pileus trama covered by a thin surface pellicle through which large cystidia project, beneath this a compact pseudoparenchymatous layer of slightly enlarged cells, the remainder floccose and filamentose.

Single to gregarious under redwoods, Prairie Creek State Park, Oric, Calif., Nov. 30 (*3683*), Dec. 3 (*3733*), and Dec. 4, 1935 (*3770*). The microscopic characters of the type at the New York State Museum, Albany, N. Y., are exactly as described above. The species which Kauffman (**9**) described under the name *Col-*

[2] All color names in quotation marks are taken from Ridgway, R. Color Standards and Nomenclature, Washington, D. C. 1912.

lybia umbonata Peck differs from the above by the absence of cystidia on the gills, the larger spores, habitat on wood, the odor of benzaldehyde, and slowly bitterish taste. It is here considered to be an undescribed species.

Collybia oregonensis sp. nov.

Odor distinctissimus; pileus 4–10 cm. latus, conico-campanulatus vel umbonatus, testaceo-fuscus, lubricus; lamellae angustae, adnexae, confertae, latae, albidae vel pallidae, acie concolores; stipes 10–20 (30) cm. longus, 5–15 (20) mm. crassus, fusiformiter radicatus, glaber, levis vel subsulcatus, pallide brunneus; sporae 6–8 × 3.5–4.5 μ; cystidia nulla.—Specimen typicum in Herb. Univ. Mich. conservatum: legit C. H. Kauffman, prope Takilma, Oregon, Nov. 29, 1925.

GOMPHIDIUS ROSEUS (Fries) Quél.

Pileus 3–7 (10) cm. broad, convex, becoming plane, occasionally slightly umbonate, surface covered by a glutinous layer, disk "Carnelian red" at first and fading to "carrot red," the margin paler and "flesh color" to "pale flesh color" or in age whitish with a faint incarnate tinge, glabrous; flesh thick, white, occasionally tinged reddish near the cuticle, tapering rather abruptly near the margin; odor and taste none; lamellae white, rather close, narrow, forking once or sometimes twice, dull blackish brown in age, deeply decurrent; stipe 6–12 cm. × 10–15 mm., equal above a clavate base, at first white and coated with a glutinous sheath to the superior annular zone, white and subscabrous above, base of stem white or whitish, at times faintly yellowish, the gluten blackening in age causing discolored patches; spores 14–18 × 4–5.5 μ, subfusiform to subcylindric, apices obtuse, dull smoky brown under the microscope; cystidia scattered on the sides of the gills 90–120 × 8–10 μ, cylindric.

Scattered under conifers, Lake Crescent, Wash., Oct. 1 (*2772*), and Oct. 3, 1935 (*2839*). Kauffman (**7**) pointed out that *Gomphidius subroseus* differs from *G. roseus* "by the distinct yellow base of the stem, by the less rosy red color of the pileus and perhaps by the cystidia." The writer's material differed from *G. subroseus* in the brighter colors and white or faintly yellowish tinged exterior of the base of the stem, the almost scabrous apex of the stipe, and by the blackening gluten on the stem. The cystidia are alike in both species. *G. roseus* was very abundant in the vicinity of Lake Crescent during the season of 1935 and

closely rivaled *Gomphidius oregonensis* Peck as the commonest agaric in the woods.

HYPHOLOMA DISPERSUM (Fries) Quél.

Pileus 1–3.5 (4) cm. broad, conic to convex, broadly umbonate in age, glabrous on the disk, faintly silky near the appendiculate margin, at first "ochraceous-orange" to "ochraceous-tawny," becoming "honey yellow" to "Isabella color" near the margin or at times sordid olive yellow, the disk becoming sordid tawny, subhygrophanous, fading slowly to sordid "ochraceous-buff" or "warm buff," lubricous when moist and not striate; flesh rather watery but firm, whitish or sordid olivaceous to yellowish, odor not distinct, taste slightly bitterish and unpleasant; lamellae broad, adnate, close, white at first, becoming sordid olive and finally purplish brown, edge whitish; stipe 6–10 cm. × 2–5 mm., covered by a dense silky fibrillose layer to near the pruinose apex, at times with faint fibrillose patches or subannular fibrillose zones over the lower portion, dark reddish brown to bistre beneath the fibrils in the lower portion, paler above and yellowish, equal above a somewhat enlarged base, rather tough and pliant, brittle in slender forms; spores 7–9 × 4–5 μ, smooth, sordid reddish brown under the microscope; cystidia abundant on the sides, 32–48 × 8–10 μ, smooth, midportion inflated, apex abruptly narrowed to an almost papillate point, on the edges 18–22 × 6–8 μ, smooth and fusoid-ventricose.

Densely gregarious on the very decayed remains of fir logs, on chips and debris where timber has been cut or on the humus and debris usually present on the forest floor, Olympic Hot Springs, Sept. 29 (*2672*); Lake Crescent, Oct. 10 (*3007*); Sol Duc Hot Springs, Oct. 17 (*3205*); and near La Push, Wash., Oct. 26, 1935 (*3344* and *3345*). In California one collection was found at Trinidad Nov. 29, 1935 (*3656*). During October this was one of the commonest agarics in the Olympic Peninsula. Zeller (**16**) reports it from Oregon. The writer's collections agree very well with Fries' (**2**) description and illustration (**3**). The cystidia on the sides of the gills are similar to those found in *Hypholoma fasciculare* and *Hypholoma capnoides*. *Psilocybe ochraeceps* Kauffman (**8**) is identical with *H. dispersum*. Cystidia similar to those described above were found abundantly on the sides of the gills in Kauffman's type. Since *H. dispersum* is

commonly described as having a stiff elastic stem that character alone should not be used to separate a species. In my material slender forms were found to have a stem which would snap when bent whereas in larger fruiting bodies this character was not evident. All variations in size and consistency were commonly found in single localities. Kauffman's collections of *P. ochraeceps* from the Olympic Peninsula clearly show the appendiculate margin of the pileus and the silky fibrillose stipe. The colors of the cap are apt to be rather variable and darker than given in Kauffman's description. A sterile form (*3345*) was found in which the yellow color was very pronounced. The gill surfaces were pale yellow, and the edges bright sulfur yellow. The pilei were either entirely yellow or with orange to "ochraceous-tawny" disks. The stems and the strigose hairs at their bases were also bright sulfur yellow. This form was found intermingled with fertile fruit-bodies. Immature individuals of the two forms could not be separated.

LEPIOTA SOLIDIPES Peck (FIG. 1).

This species is characterized by a layer of upright subgelatinous hyphae over the surface of the pileus which causes it to feel slippery when wet and to appear polished when dry. When dry the surface layer is sometimes cracked irregularly but does not become scaly. The color varies from white to "pale pinkish buff." The peculiar hyphae over the surface of the cap, the firm consistency and the very strong farinaceous odor and taste are distinctive. The spores measure 4–5.5 μ and are yellowish in iodine with chloral hydrate. The writer's collection from Crescent Beach, Joyce, Wash., Oct. 3, 1935 (*2844*) compares very well with the type at Albany, N. Y.

Naucoria attenuata sp. nov. (FIG. 2).

Pileus 1.5–5 cm. latus, obtuse conicus, demum late umbonatus vel planus, glaber, lubricus, fulvus, hygrophanus, demum sordide alutaceus, cartilagineus; caro odore subraphanoidea, sapore valde amara; lamellae confertae, angustae, subliberae, pallidae vel pallide caesiae, demum fulvae; stipes 10–12 cm. longus, 3–5 mm. crassus, valde radicatus (3–8 cm.), glaber, politus, valde cartilagineus, fulvus demum spadiceus; sporae 7–8 × 4–4.5 μ, asperulae.—Specimen typicum in Herb. Univ. Mich. conservatum: legit A. H. Smith n. *3343*, prope La Push, Washington, Oct. 26, 1935.

Pileus 1.5–5 cm. broad, obtusely conic, becoming broadly umbonate or broadly convex to plane in age, margin inrolled at first and in age often undulate, glabrous and polished, lubricous, "amber brown" when moist or near "ochraceous-tawny," hygrophanous, fading to "ochraceous-buff" or "warm buff," margin seldom striatulate at any stage; flesh thin but cartilaginous, buff or watery brown, odor strong, somewhat radish-like, taste very disagreeable; lamellae close, narrow, equal, attached by a tooth, nearly

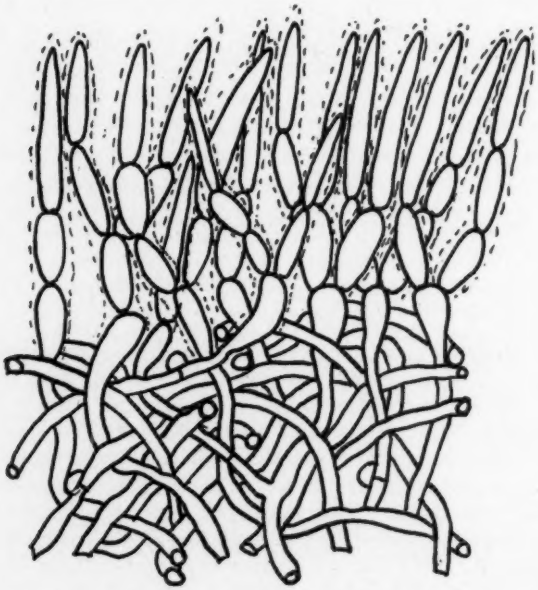

FIG. 1. *Lepiota solidipes* Peck. Tangential section showing the cuticle of the pileus. × 375.

free in age, pallid and with a faint caesious tinge at first, pale cinnamon brown in age, edge even; stipe 10–12 cm. × 3–5 mm. equal above a long (3–8 cm.) tapering pseudorhiza, glabrous and polished, hollow, very cartilaginous, at first pallid brownish over all; spores 7–8 × 4–4.5 μ, almond shaped, roughened; basidia four-spored; cystidia not differentiated; pileus trama with a thin subgelatinous pellicle, beneath this a compact area appearing cellular in tangential section, the remainder filamentose.

FIG. 2. *Naucoria attenuata* Smith. × 1.

Closely gregarious under spruce, near La Push, Wash., Oct. 26 (*3343-type*), Oric, Calif., Dec. 4 (*3769*), Dec. 5 (*3813*), Dec. 7 (*3876*); north fork of the Mad River, Calif., Dec. 9, 1935 (*3900*). This species can be distinguished macroscopically by its stipe which blackens in age, by the very disagreeable taste, the polished lubricous pileus and stipe, the ochraceous colors and the closely gregarious manner of growth. Microscopically the distinctly roughened spores separate it at once from *Naucoria radicata* Murrill. Murrill (**10**) in his description of the latter mentions that its stipe also blackens. All of the writer's collections in which the stems blackened were found to have rough spores. The European species which appear to be most closely related are *Naucoria similis* Bres. and *Naucoria flava* Bres. The former is at once excluded by its color and the viscidity of the pileus. *N. flava* judging from descriptions, can be distinguished by its yellow color and silky to subfloccose pileus. *Naucoria Jennyae* Karsten is close but is said to have smaller spores and brighter orange colors.

Naucoria Kauffmani sp. nov. (FIG. 3).

Pileus 8–15 (19.5) cm. latus, obtuse, conicus vel convexus, demum late umbonatus, glaber, glutinosus, pallide testaceus demum hepaticus, subhygrophanus, cartilagineus; lamellae confertae, liberae vel subliberae, latae; stipes 20–40 cm. longus, 1.5–3.5 (4) cm. crassus, valde radicatus, apice pallide incarnatus, deorsum livido-brunneus vel spadiceus, valde cartilagineus; sporae 8–10 × 4.5–6 (7) μ, asperulae.—Specimen typicum in Herb. Univ. Mich. conservatum: legit A. H. Smith n. *3523*, prope Lake Tahkenitch, Oregon, Nov. 18, 1935.

Pileus 8–15 (19.5) cm. broad, convex to obtusely conic, becoming expanded and broadly umbonate, glabrous, very glutinous at first, margin long remaining inrolled and never striate, when moist "cinnamon," "light pinkish cinnamon," "cinnamon-rufous" or "Kaiser brown," becoming "liver brown" when old and water soaked, subhygrophanous, fading to "ferruginous" or "apricot orange"; flesh thick and firm, with a thick cartilaginous rind near the surface, "army brown" when moist, incarnate buff when faded, taste slightly farinaceous, odor not distinct; lamellae crowded, free or slightly attached by a tooth, narrow at first, broad (2 cm.), in age, at first "tilleul buff" becoming nearly "verona brown" in age; stipe 20–40 × 1.5–3.5 (4) cm. gradually tapering downward to a long thread-like pseudorhiza, "buff-pink" to "onion-skin pink" above, sordid purplish brown below, becoming

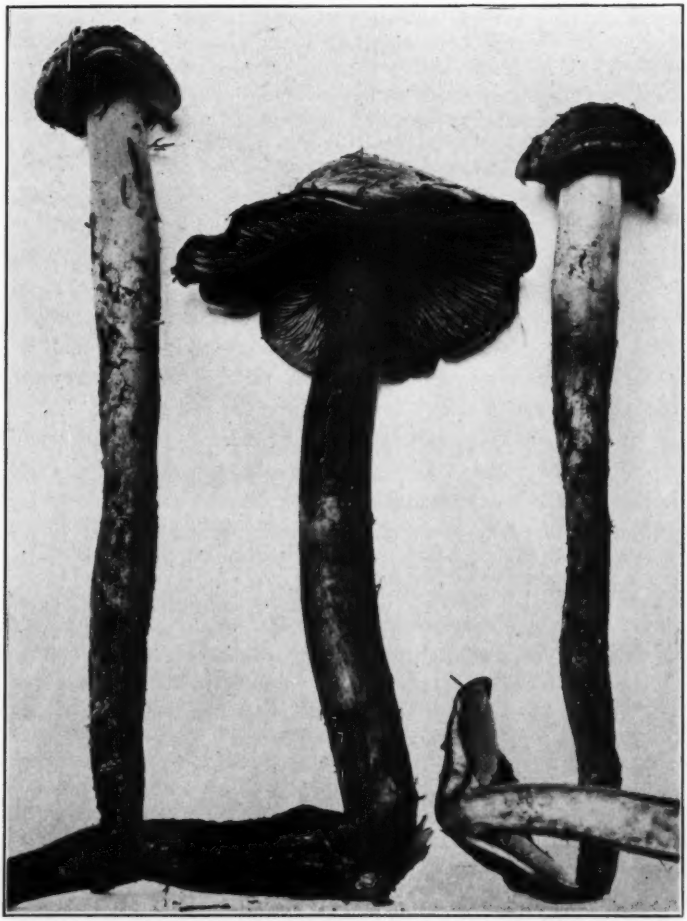

FIG. 3. *Naucoria Kauffmani* Smith. Very small immature fruit-bodies. × 1.

darker to nearly black in age, stuffed with a pallid pith, with a thick cartilaginous rind, glabrous or faintly longitudinally striate at the apex; spores 8–10 × 4.5–6 (7) μ, pale cinnamon brown in mass, almond shaped, slightly roughened; basidia four-spored; cystidia on the gill edge only, 30–36 × 5–7 μ, narrowly clavate, smooth; pileus trama with a thick gelatinous layer over the surface, beneath it a compact pseudo parenchymatous layer of somewhat enlarged cells, the remainder floccose.

Gregarious to scattered under conifers, Lake Quiniault, Wash., Oct. 11, 1925, and Takilma, Oregon, Dec. 7, 1925 (C. H. Kauffman). Under spruce at Cape Flattery, Wash., Sept. 18 (*2495*); Hoh River Valley, Wash., Oct. 7 (*3024*); La Push, Wash., Oct. 26 (*3339*); Lake Tahkenitch, Oregon, Nov. 18 (*3523-type*); and along the north fork of the Mad River, northern Calif., Dec. 9, 1935 (*3888*). The colors of *Naucoria lugubris* Fries and *N. Kauffmani* are very similar and quite variable. The spores are the most reliable character for separating the two species. Those of *N. Kauffmani* always measure 8 μ or more long and are up to 6 or 7 μ broad, those of *N. lugubris* to judge from the writer's collection and the statements of Heim (**4**), Ricken (**12**), Velenovsky (**15**) and Bresadola (**1**) seldom measure over 8.5 μ. The difference in the size of the fruit-body is relatively constant but should be used with caution since *N. lugubris* along our west coast is larger than the size usually given for the species in Europe. In *N. lugubris* the stipe and gills become bright fiery orange or reddish brown in age or where bruised whereas in *N. Kauffmani* the gills do not change and the stem becomes sordid purplish brown to blackish.

NAUCORIA CAESPITOSA Murrill.

Gregarious to subcespitose around redwood logs, Trinidad, Calif., Nov. 27 (*3627*), Nov. 30 (*3679*), Oric, Calif., Dec. 4 (*3768*) and Dec. 5, 1935 (*3828*). The colors of the fresh pilei are "pinkish buff" or dull whitish. At times the disk is "pinkish cinnamon." The margin of the pileus is at first beautifully fimbriate, and the stipe is sheathed by a loose fibrillose sheath up to the evanescent annular zone. The surface of the pileus is covered by a gelatinous pellicle which causes it to feel viscid. In wet weather this layer may be entirely washed away. The spores of the type measure 7–8 (9) × 4–5 μ, the basidia are four-spored and cystidia 25–31 ×

8–15 μ are imbedded in the hymenium. The cystidia are smooth, colorless and ventricose with obtuse apices.

NAUCORIA CUCUMIS (Fries) Gillet.

The small form described by Josserand (**6**) was not uncommon in old pastures and along the edges of thickets. The pilei measured from 5 to 15 mm. broad. It was collected at Joyce, Wash., Oct. 11 (*3105*), and Lake Crescent, Wash., Oct. 14, 1935 (*3144*).

NAUCORIA FESTIVA (Fries) Bres.

Pileus 1–5 (6) cm. broad, conic at first, expanded and with a conic umbo at maturity, at times paler in age, glabrous, glutinous when wet, viscid in dry weather, "deep olive" to "buffy olive" when fresh, subhygrophanous, fading to "water green" or "vetiver green," margin faintly striatulate when fading; flesh thick on the disk, thinner toward the margin, "olive-green" to greenish gray, fading to greenish buff, very cartilaginous and brittle, taste mild or slightly bitter, odor faint and radish-like if flesh is crushed; lamellae close, free or adnexed and attached by a tooth, narrow, in age moderately broad near the margin, at first "pale violet-plumbeus" to "deep plumbago gray," soon grayish, finally brown, edge serrate or eroded; stipe 8–12 cm. $\times$ 4–8 (12) mm., tapering slowly into a long pseudorhiza, at first faintly grayish to caesious at the apex and watery orange to reddish brown below, apex pale grayish green in some and brilliant orange red to blood red below, at first scantily covered by very minute bran-like scales or appressed fibrillose patches to near the apex, glabrous in age, tubular, rind thick and cartilaginous; spores 7–8.5 $\times$ 4–5 μ, almond shaped, roughened; basidia four-spored; cystidia on gill edge only, scarcely differentiated, 35–42 $\times$ 7–9 μ, clavate, apices obtuse, smooth; pileus trama with a thick gelatinous surface pellicle, beneath it a compact area of enlarged cells appearing pseudoparenchymatous in tangential section, the remainder floccose.

Gregarious under spruce, La Push, Wash., Oct. 26, 1935 (*3342*); and under a stand of vigorous young redwoods, Trinidad, Calif., H. E. Parks and A. H. Smith, Nov. 27 (*3634*) and Dec. 6, 1935 (*3840*). This species was rare in Washington but very abundant in the single locality on Mr. Parks' estate at Trinidad. The above collections were all characterized by the distinctly grayish violet gills of the young fruit-bodies and the faintly caesious tinge at the apex of the stems. The olive green viscid pileus, the stipe with its

scant fibrillose patches and the brilliant orange to reddish base in age, the long pseudorhiza, and spores clearly place our collections in this species. Judging from the descriptions of various European investigators, the colors and color changes of the gills and stems are quite variable. Violet colors on the stipe are mentioned by Ricken (**12**). The older pilei in the Trinidad material were spotted dark olivaceous umber. No yellowish spots were observed on any fruiting bodies.

NAUCORIA LUGUBRIS (Fries) Quél. sensu Ricken.

Pileus 4–8 (10) cm. broad, obtusely conic with an inrolled margin, in age expanded and obtusely umbonate or remaining broadly conic, glabrous, viscid or glutinous, opaque, near "fuscous" or "bone brown" when fresh, at maturity remaining dark or becoming almost "chestnut-brown," fading very slowly to "wood brown" near the margin, the disk remaining darker; flesh thick on the disk, tapering gradually, with a distinct cartilaginous layer near the surface, odor slightly farinaceous when cut or bruised, taste faintly bitter; lamellae free or scarcely attached by a tooth, narrow at first, moderately broad in age, close, pallid to near "avellaneous," becoming "snuff brown" finally "cinnamon-brown," staining ferruginous when bruised, edge serrate to eroded and slightly paler; stipe 15–20 × 1–2 cm., tapering downward to a long (10–20 cm.) pseudorhiza, glabrous, polished, with very fine longitudinal striations, stuffed with a pallid buff pith, rind thick and very cartilaginous, concolorous with pileus or paler above and near "avellaneous," sordid reddish brown below, the reddish tinge increasing both in intensity and extent in age; spores 7–8 × 4–5 μ, broadly almond shaped, rough; cystidia on the gill edge only, 30–35 × 4–6 μ, clavate; basidia four-spored; pileus trama similar to that of *Naucoria Kauffmani*.

Cespitose to gregarious in a spruce forest, Booth, Oregon, Nov. 13, 1935 (*3458*). The descriptions and illustrations of Fries (**2**), Rea (**11**), Bresadola (**1**) and Heim (**4**) depict a paler fungus. The essential characters however, are the smooth thick cartilaginous long-rooting stipe, the viscid pileus, small spores, and the color change on gills and stipe. Ricken (**12**) describes color variations of chestnut brown to chocolate gray which are close to those of my collection. In the larger clumps the stems were connate at their bases and penetrated deep into the soil. Because of the

fragile nature of the pseudorhiza and the difficulties of digging in the root-filled humus, the attachment was not ascertained. All of the forty odd fruiting bodies were either very near or under large fern clumps.

NAUCORIA MYOSOTIS (Fries) Quél.

Two fruiting bodies of this characteristic species were found along a path through swampy ground at Lake Ozette, Wash., Sept. 25, 1935 (*2596*). Since first collecting this species in Michigan (**13**) the writer has found it in the Adirondacks near the summit of Mt. Marcy and in a bog near Catlin Lake in the vicinity of Newcomb, N. Y. Specimens were sent to Dr. Kühner, Paris, who stated that microscopically the American material was similar to that of *N. Myosotis* in Boudier's herbarium. *Naucoria elatior* (Peck) Sacc. (*Agaricus elatior* Peck) is identical with the writer's material microscopically and should be considered a synonym of *N. Myosotis*.

NAUCORIA RADICATA Murrill.

Pileus 2–3 cm. broad, broadly convex with a small often inconspicuous conic umbo, glabrous and polished, lubricous to subviscid, margin faintly striatulate, "Kaiser brown" to "hazel" on the disk, margin "ochraceous-tawny" fading very slowly to near "apricot-buff," with a broad usually decurved sterile margin; flesh thick on the disk, thin toward the margin, soft and fragile, concolorous with the surface, odor and taste not distinctive; lamellae broad, crowded, narrowly adnexed, near "cinnamon-rufous" at maturity, edge slightly uneven; stipe 6–18 cm. long, 3–5 mm. thick, with a long (3–9 cm.) tapering pseudorhiza, concolorous with the pileus or paler, glabrous, polished, in age darker reddish brown or nearly chestnut below, not blackening, fistulose, very brittle; spores 5–6 $\times$ 3–3.5 μ, subovoid, smooth, very pale ochraceous under the microscope, bright cinnamon brown in mass; basidia four-spored; cystidia on the gill edge only, 25–30 $\times$ 3–5 μ, hair-like, apices acute; pileus trama with an adnate subgelatinous pellicle, beneath it a compact hyphal layer appearing pseudoparenchymatous in tangential section, the remainder of floccose tissue.

Scattered under redwoods, Rush Grove, Prairie Creek State Park, Oric, Calif., Dec. 3 (*3743*), Dec. 3 (*3746*) Dec. 4 (*3763*)

and Dec. 7, 1935 (*3875*). The stipe darkens when the fungus is dried, but no such change was noted on even the old fruit-bodies in the woods. For additional comments see *Naucoria attenuata.*

NAUCORIA STICTICA (Fries) Sacc.

Gregarious under blackberry bushes at the side of a road, Lake Crescent, Wash., Oct. 13 (*3121*), and Oct. 23, 1935 (*3312*). To judge from the descriptions, the writer's collections differ from *Naucoria obtusa* Cooke and Massee in the larger size, longitudinally striate stem and broadly ovoid to subglobose roughened spores. *Naucoria innocua* according to Ricken has larger wedge shaped spores. Fries' (**3**) illustration of *N. stictica* depicts my material very well except for the minute white granules. The spores are rough, measure 6–7 × 4–5 μ and are broadly ovoid to subglobose. Cystidia are not differentiated and a thin gelatinous pellicle covers the pileus. At first the cap is evenly " Sanford's brown." It fades slowly to near " cinnamon-buff."

Psathyra pelliculosa sp. nov.

Pileus 8–20 mm. latus, conicus, glaber vel subfibrillosus, viscidus, saturate isabellinus vel pallide olivaceus demum incarnato-alutaceus; lamellae sordide fulvae, demum umbrinae, confertae, adnatae, angustae demum latae; stipes 6–8 cm. longus, 1.5–2 mm. crassus, apice pruinosus et pallide cinereus, deorsum sericeo-fibrillosus et umbrinus; sporae 8–10 × 4–5 μ; cystidia 25–30 × 6–9 μ, ventricosa.—Specimen typicum in Herb. Univ. Mich. conservatum: legit A. H. Smith n. *3431,* prope Lake Tahkenitch, Oregon, Nov. 11, 1935.

Pileus 8–20 mm. broad, sharply conic, scarcely expanding, margin appressed against the stem at first and for a time slightly appendiculate from the remains of the submembranous to fibrillose veil, glabrous at maturity, viscid, pellicle separable and tenacious, " Saccardo's umber " to " Isabella color " when moist, margin at times with a distinct greenish gray tinge, hygrophanous, fading to " pinkish buff," striatulate when moist; flesh thin and pliant, odor not distinctive; lamellae dull " cinnamon-brown," at maturity dark and smoky from the spores, close, adnate, seceding, narrow to moderately broad, edge whitish; stipe 6–8 cm. × 1.5–2 mm., equal above an enlarged base, appressed silky fibrillose below, pruinose above, brownish to near " bister " toward the base, apex pallid to grayish, tubular, rather pliant but rigid; spores 8–10 × 4–5 μ, dull purple brown under the microscope, ellipsoid; cystidia abundant

on the gill edge, 25–30 × 6–9 μ, smooth, inflated, fusoid-ventricose with an acute apex; pileus trama homogeneous below a thick gelatinous pellicle.

Gregarious on moss and debris, Lake Crescent, Wash., Oct. 10 (*3074*); Sol Duc Hot Springs, Wash., Oct. 17 (*3196*); Lake Tahkenitch, Oregon, Nov. 11 (*3431-type*); Siltcoos Lake, Oregon, Nov. 13, 1935 (*3461*). The submembranous partial veil which adheres slightly to the margin of the pileus and the consistency relate this species to *Hypholoma dispersum*. The tenacious gelatinous pellicle on the pileus, the sordid colors which tend to become greenish and the silky fibrillose stipe relate it to *Psathyra fagicola* Lasch. It is distinguished from the latter by the presence of a partial veil, firm gills and smaller stature. Kauffman collected this species at Lake Cushman, Wash., Oct. 1, 1915, and again at Lake Quiniault, Wash., during Oct., 1925.

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PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXV. URNULA GEASTER

FRED J. SEAVER

(WITH 3 FIGURES)

Since the publication of North American Cup-fungi (operculates) some interesting data and observations on *Urnula Geaster* have come to the attention of the writer through Professor G. W. Goldsmith of the University of Texas, to whom I am indebted for the material and part of the photographs, on which the present paper is based.

DISTRIBUTION

This species was originally described by C. H. Peck from material collected at Austin, Texas. The material, on which the present paper is based, was collected in the same locality. So far as the writer knows this species has not been found outside of the State of Texas, although there seems to be no reason to believe that it might not occur over a wider range. When this material was received from Professor Goldsmith specimens were sent to Dr. J. A. Nannfeldt, the outstanding student of the cup-fungi of Europe at the present time, and he reported that he knew nothing like it in Europe. We conclude, therefore, that the fungus has a very limited distribution, and this in itself is interesting since the fungi are often cosmopolitan in their distribution.

STRUCTURE

The details of the structure of this fungus were thoroughly discussed by Doctors F. D. Heald and F. A. Wolf (Bot. Gaz. **49**: 182. 1910). It is not necessary to go into the details of this at the present time, except to call attention to one important feature which they must have overlooked, although it is impossible for the writer to understand how this could possibly have been done. This has to do with the structure of the paraphyses.

FIGS. 1-2. *Urnula Geaster.*

PARAPHYSES

Doctors Heald and Wolf in their article state "Numerous branched septate paraphyses are present, which are uniform in diameter throughout (slightly less than 2μ) and do not show a terminal enlargement as figured by Kupfer." In examining the material sent by Professor Goldsmith, the writer was immediately impressed by what appeared to be strings of huge conidia interspersed with the asci, but which were found on closer examination to represent swollen paraphyses, each joint of which becomes ellipsoid or almost rounded, giving the whole the appearance of a string of miniature balloons. At first it was not apparent that these were paraphyses. However, it was finally noted that the terminal cells were scarcely swollen at all, and that the individual balloons were really the swollen cells of the paraphyses. The writer naturally began to look for a reason for this peculiar phenomenon.

EXPANSION APPARATUS

In looking at the figures accompanying this article it will be noted that this fungus, commonly known as the "devil's cigar," is at first cylindrical. Later it splits into several rays which fold back so that the apothecium is literally turned inside out. From this it will be readily seen that the swelling of the paraphyses is another ingenious device which facilitates the expansion or warping of the hymenium, thus placing the asci in such position that the spores may be freely discharged.

Although the writer has worked on the cup-fungi for many years, and while he has noted that the paraphyses are sometimes slightly swollen, nothing even approaching the condition encountered here has been observed before. What puzzles him most is the fact that this character was overlooked by Heald and Wolf while working on this material in Texas. This would lead one to suspect that possibly there are two species in Texas, one of which has swollen paraphyses, and the other the slender form. This, however, seems rather unlikely. This character should be carefully checked in the field in order to determine just how and when this swelling takes place. Unfortunately since this species is

FIG. 3. *Urnula Geaster.*

known only in Texas it is impossible to carry out these investigations from fresh material in New York, and the question, therefore, remains to be investigated more carefully by some local student.

SPORE DISCHARGE

So far as the writer is aware, Mr. W. R. Fisher, of Cornell University, was the first man to photograph the process of spore discharge in the ascomycetes. This has been done on two species of *Sclerotinia*, both inoperculate cup-fungi. Professor Goldsmith has made very excellent photographs of the spore discharge in *Urnula Geaster*, which is apparently the first photograph of such spore discharge in an operculate cup-fungus. In this particular case the spores are many times larger than those of the Sclerotinieae, and should consequently produce a much denser cloud when discharged in mass.

DEHISCENCE OF THE ASCUS

In discharging the spores the ascus ruptures at one side near the apex and after discharge appears in profile rigidly upright, just as though one side of the ascus had been turned back. In face view the edge of the operculum is rounded, but it remains firmly attached on the other side. The ascostome then occupies an oblique position.

THE ASCOSPORES

The ascospores are usually large, reaching a length of 50–70 μ. They are attenuated at either end and their form and size would indicate that the contraction of the ascostome might facilitate their discharge, as has been pointed out for certain other species.

DISCUSSION

There are many points in connection with this species to be cleared up. Unfortunately, however, from the standpoint of the writer this species occurs only in Texas, and no opportunity has been afforded for first hand study of the fungus in the field. It

offers an excellent opportunity for study of the dehiscence of the ascus, the position of the ascostome, and the methods of spore discharge. It is hoped that these points may be worked out more in detail by some local student.

THE NEW YORK BOTANICAL GARDEN

EXPLANATION OF FIGURES

Fig. 1–3. *Urnula Geaster*. 1, photograph by G. W. Goldsmith of eospore discharge, much reduced; 2, habitat group, also by G. W. Goldsmith, much reduced; 3, photograph of several plants made under the directions of the writer from material sent by G. W. Goldsmith, about 2/3 natural size, with drawings of the ascus in various stages and the swollen paraphyses.

THREE DERMATEACEAE OCCURRING ON NEMOPANTHUS[1]

J. WALTON GROVES[2]

(WITH 9 FIGURES)

During the course of a cultural study of conidial relations in the Dermateaceae, it was found that three quite distinct species of this group occurred on *Nemopanthus,* and at least two of them also on *Ilex,* and that these three fungi had been confused to a considerable extent in the past, especially in regard to their conidial relationships. This paper is presented with the aim of clarifying these relationships.

The three fungi which will be discussed are as follows: *Dermatea Peckiana* (Rehm), of which the imperfect stage is *Micropera stellata* (Ellis) Jacz.; *Godroniopsis Nemopanthis,* of which the imperfect stage is *Sphaeronema Peckii* Sacc. & Syd.; and *Durandiella Nemopanthis* (Peck), of which no imperfect stage has been found.

In the field these fungi are frequently found closely associated, sometimes all three occurring on the same twigs of the host. It sometimes happens that the perfect stage of one will be found associated with the imperfect stage of another, so that cultural studies are essential to the determining of their proper relationships. The fungi are quite distinct morphologically and once their relationships have been determined in this way they are readily recognizable.

[1] Contribution from the Department of Botany, University of Toronto, Toronto, Ontario.

[2] The writer wishes to acknowledge his indebtedness to Professor H. S. Jackson, under whose direction the work was carried on, for his continued interest and helpful suggestions; to Dr. Bessie B. Kanouse of the University of Michigan who kindly loaned the specimen of *Micropera caespitosa* (Peck) Archer on which this combination was based; and to Mr. J. Herbert Stewart, head of the department of Classics at Woodstock Collegiate Institute, who assisted with the Latin diagnosis.

The material used in this study was collected, for the most part, in the Temagami Forest Reserve, Ontario. The method employed was to obtain cultures from both ascospores and conidia as found in nature, and to compare the cultural characters and type of conidial stage produced in culture. The cultures were grown on two per cent agar containing two per cent malt extract, and on sterilized twigs of the host. The twig cultures were grown in flasks which were prepared in the following manner. Healthy twigs were selected and cut into lengths of 7–10 cm. and three of these were placed in a 300 cc. Erlenmeyer flask with about 25 cc. of water. The flasks were then sterilized for half an hour in the autoclave at fifteen pounds pressure. When cool the twigs were inoculated by placing bits of agar and mycelium in slits which had previously been cut in the bark, and these flasks were kept on a shelf in the laboratory at room temperature and in diffuse light. Polysporous cultures of both ascospores and conidia were used in the hope of facilitating the development of the perfect stage. No ascogenous stage developed in any of the cultures, however. In studying the morphology of the fruiting bodies free-hand sections and crushed mounts were used exclusively.

Dermatea Peckiana (Rehm) comb. nov.

Cenangium Peckianum Rehm, Ann. Myc. **13**: 3. 1915.

Sphaeronema stellatum Ellis, Bull. Torrey Club **6**: 107. 1876.

Sphaerographium stellatum Sacc., Syll. Fung. **3**: 598. 1884.

Micropera Nemopanthis Peck, Ann. Rep. N. Y. St. Mus. **46**: 109. 1893.

Micropera stellata Jaczewski, Nouv. Mem. Soc. Imp. Natur. Moscow **15**: 366. 1898.

Apothecia arising from the old conidial stroma, caespitose, crowded, up to 15 in a cluster, about 0.3–0.8 mm. in diameter and the clusters up to 1 mm. in height, circular or irregular in outline, slightly narrowed below, dark brown to black but the basal stroma pale yellowish, hard, leathery to horny in consistency becoming more fleshy-leathery when moist; hymenium at first concave becoming plane or convex, dark brown to black, slightly roughened, with a brownish margin which is at first raised and more or less infolded, later almost disappearing; tissue of the stroma compact, pseudoparenchymatous, composed of hyaline, thick walled cells

about 8–20 × 5–10 μ arranged in more or less vertically parallel rows, curving obliquely toward the outside where the cells are smaller, more globose, and with thicker and darker walls; subhymenium composed of slender, closely interwoven hyphae; asci cylindric-clavate, tapering to a slender stalk, eight spored, 67–110 × 9.5–12.5 μ; ascospores ellipsoid to subcylindric or subfusiform, hyaline or pale yellowish, straight or slightly curved, one to two (to four?) celled, 10–23 × 3–6 μ; paraphyses hyaline, filiform, septate, branched, 1.5–2 μ in diameter, the tips swollen to 3–5 μ and forming an epithecium.

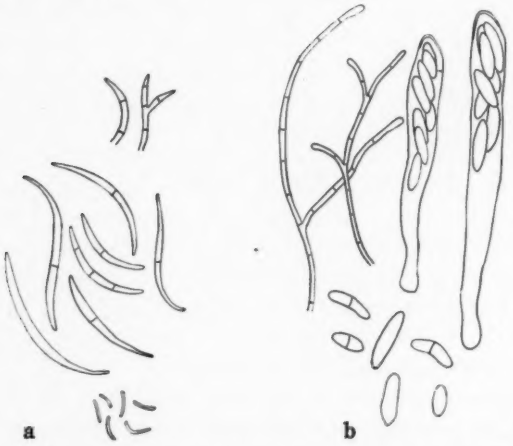

FIG. 1. *Dermatea Peckiana*. a, drawings of conidiophores, conidia, and microconidia; b, asci, ascospores, and paraphyses. × 400.

Conidial stromata erumpent, rounded, verruciform, often somewhat capitate, usually thickly scattered, circular to more or less transversely elongated, 0.5–2 mm. in diameter and up to 1 mm. in height, upper surface uneven and wrinkled around the openings of the cavities, pale yellowish below to black on top, often with a dark vinaceous colour when fresh, leathery to fleshy in consistency, softer than the apothecia; pycnidial cavities numerous in the upper part of the stroma, ovoid, about 100–150 × 35–100 μ, later sometimes becoming more or less confluent and more irregular in shape, opening irregularly and sometimes very widely; conidiophores hyaline, cylindric, septate, sometimes branched, 20–40 × 2.0–2.5 μ, tapering to a slender tip; conidia hyaline, elongated to sub-filiform, sickle shaped or sigmoid, sometimes almost straight, ends pointed

and usually one end more attenuated than the other, one or two celled, 25–60 × 2.5–4.5 μ, emerging in grayish masses which often show also a dark vinaceous colour; microconidia hyaline, filiform, straight or curved, one celled, 8–13 × 1.5–2 μ.

EXSICCATI: Ellis N. Am. Fungi *3042,* Type; Fungi Col. *332;* Ellis N. Am. Fungi *2170* (*Sphaeronema stellatum*).

SPECIMENS EXAMINED: University of Toronto Herbarium. On *Nemopanthus mucronata. 4368, 4467, 4468, 4469, 4470, 4471, 6576, 6578, 6592, 7930, 7931, 8438,* Temagami Forest Reserve, Ontario—*6926,* east of Wilcox Lake, Ontario—*6933,* Bell's Lake, north of Parry Sound, Ontario—*7929,* Brant Co., Ontario.

On *Ilex verticillata. 4511, 5071, 7932, 8439, 8444,* Temagami Forest Reserve, Ontario—*6953,* Bell's Lake, north of Parry Sound, Ontario.

University of Michigan Cryptogamic Herbarium. On *Ilex verticillata. Micropera caespitosa* (Peck), Ypsilanti, Mich., April 21, 1923. Coll. L. E. Wehmeyer. Det. W. A. Archer.

Cultures were similar from both ascospores and conidia and both produced conidial fructifications in culture. The cultures were similar also, whether isolated from *Nemopanthus* or *Ilex.* On malt extract agar the fungus grew slowly forming colonies which were whitish to pale buff, occasionally with yellowish or brownish tinges, covered with a short, loosely matted, aerial mycelium, which was sometimes more abundant near the centre forming a cottony tuft. The surface of the colony was usually even but was sometimes more or less radially furrowed, especially in Petri dish cultures. In Petri dish cultures the colonies were more heaped up than in tubes where they spread slowly and evenly. Conidial fructifications were formed abundantly as rounded, fleshy stromata, up to 3–4 mm. in diameter and 1–2 mm. in height, externally black or grayish tomentose, and with a very irregular surface. Usually the stroma contained numerous cavities as in nature, but sometimes it was much smaller, cylindric to conic in form, and containing but a single cavity. Sometimes the cavities opened very widely so that the conidiophores appeared to be borne on an exposed surface. The conidia and conidiophores were similar to those found in nature and the characteristic dark vinaceous

colour was quite pronounced in the spore masses and upper part of the stroma. Microconidia were produced abundantly also.

On twigs of *Nemopanthus* and *Ilex* sporulation was rare. Numerous primordia were formed as erumpent, scattered, more or less rounded stromata, whitish to pale yellowish in colour, but usually they continued to develop vegetatively and eventually formed white cottony tufts on the twigs. When spores were produced they were typical of the conidia found in nature, and the characteristic dark vinaceous colour appeared in the spore mass. The spores were produced in cavities in the stroma similar to those found in nature, but usually larger and more irregular in shape. Sometimes tufts of cottony aerial mycelium developed on the twig, particularly around the point of inoculation, but the aerial mycelium did not spread over the whole twig.

The imperfect stage was originally described by Ellis (**1876**) on *Ilex*, as *Sphaeronema stellatum*. It was said to be similar to *Sphaeronema caespitosum* Peck in habit but to differ in the conidia which were 37.5–50 μ long. Peck (**1893**) described an imperfect fungus on *Nemopanthus* as *Micropera Nemopanthis* which is evidently the same fungus as *Sphaeronema stellatum* Ellis. Jaczewski (**1898**) transferred *Sphaeronema stellatum* Ellis to *Micropera*, where it properly belongs. Archer (**1926**) confused this fungus with *Sphaeronema Peckii* Sacc. & Syd. (*S. caespitosum* Peck) and this will be more fully discussed in connection with the latter species.

The perfect stage was described by Rehm (**1915**) as *Cenangium Peckianum*. This description was based on the specimen in Ellis N. Am. Fungi *3042* on *Nemopanthus*, which had been labelled *Tympanis Nemopanthis* Peck, but differed from this species in having ellipsoid rather than filiform ascospores. The University of Toronto specimen of Fungi Col. *332* is the same fungus, also distributed under the name of *Tympanis Nemopanthis* Peck.

The genus *Cenangium*, to which Rehm referred the species has been used to include a great number of diverse and unrelated forms. This fungus would belong in the genus *Dermatea*, as typified by *Dermatea Cerasi* (Pers.) Fries. Both of these fungi are found breaking through the bark on twigs of their host, both have black, leathery apothecia and ascospores which are similar in

form, colour, and septation, and both have conidia of similar form. This fungus is, therefore, considered to be a typical *Dermatea* and is transferred to that genus. It is distinct from other species of the genus by reason of its characteristic conidial stage and occurrence on *Nemopanthus* and *Ilex*.

Godroniopsis Nemopanthis sp. nov.

Sphaeronema caespitosum Peck, Ann. Rep. N. Y. St. Mus. **25**: 85. 1873.

Sphaeronema Peckii Saccardo and Sydow, Syll. Fung. **14**: 900. 1899.

Micropera caespitosa Archer, Ann. Myc. **21**: 55. 1926.

Apotheciis erumpentibus, dense gregariis, caespitosis, raro solitariis; caespitibus ad 1 cm. latis, ad 2 mm. altis; apotheciis 0.5–1 mm. diam. substipitatis, primitus globosis, mox urceolatis, dein orbicularibus explanatis,

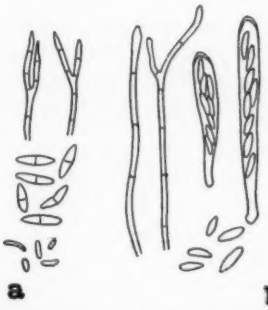

FIG. 2. *Godroniopsis Nemopanthis*. a, drawings of conidiophores, conidia, and microconidia; b, asci, ascospores, and paraphyses. × 400.

rufo-brunneis vel nigris, longitudinaliter striatis, duris, coriaceo-ceraceis, humidis coriaceo-carnosis; hymenio cupuliformiter depresso, dein plano, interdum umbilicato, carnoso, griseo vel roseo tincto; margine tenui subfimbriato, aurantiaco raro rufo-violaceo, in sicco involuto, humido expanso; ascis cylindricis vel cylindrico-clavatis, octosporis 50–75 × 5–8 μ; sporis elongato-fusiformibus vel subclavatis, hyalinis, continuis vel uniseptatis, irregulariter distichis vel submonostichis, 10–12.5 × 2.5–4 μ; paraphysibus hyalinis, filiformibus, septatis, interdum ramosis, 1.5–2 μ diam., apice minime incrassatis, epithecium non formantibus.

Apothecia erumpent, thickly scattered, caespitose, occasionally single; the clusters up to 1 cm. in length and 2 mm. in height;

apothecia 0.5–1 mm. in diameter, at first globose, then becoming urceolate, finally spreading out and becoming flat, substipitate, dark reddish-brown to black, longitudinally striate, consistency hard, waxy to leathery, becoming more fleshy-leathery when moist; hymenium circular, at first deeply concave, then plane, sometimes umbilicate, fleshy, grayish to pinkish; margin slightly fimbriate, often rather bright coloured, orange to pinkish or vinaceous, folded inwards when dry, expanding when moist; tissue compact, pseudoparenchymatous, composed of fairly thick walled, dark coloured, almost isodiametric to slightly elongated cells about 5–15 μ in diameter, arranged in more or less vertically parallel rows which curve obliquely toward the outside where the cells are smaller and darker, the outer cells sometimes growing out into a short hair-like structure of three or four almost globose cells; tissue of the excipulum surrounding the hymenium composed of slender, ascending, parallel hyphae which grow out loosely at the top forming tufts of hyaline hairs projecting over the hymenium; subhymenium a zone of slender, hyaline, rather loosely interwoven hyphae; asci cylindric to cylindric-clavate, eight spored, 50–75 $\times$ 5–8 μ; ascospores elongate-fusiform to subclavate, hyaline, one or two celled, irregularly biseriate to subuniseriate, 10–12.5 $\times$ 2.5–4 μ; paraphyses hyaline, filiform, septate, sometimes branched, 1.5–2.0 μ in diameter, the tips not at all or very slightly swollen and not forming an epithecium.

Conidial fruiting bodies erumpent, thickly scattered, caespitose, occasionally single, subulate, tapering from 225–500 μ at the base to 120–225 μ at the tip, up to 2 mm. in length, externally black and smooth; tissue of the basal stroma similar to that of the apothecia, but the walls of the beak composed of three zones, an outer zone of a few rows of almost isodiametric or slightly elongated, very dark walled cells about 8–10 μ in diameter, a middle zone of more elongated, lighter coloured cells, and an inner zone of filamentous, more or less parallel, faintly coloured, abundantly and conspicuously septate hyphae, mostly 3–5 μ in diameter, from which the conidiophores arise as side branches; conidiophores hyaline or pale yellowish, cylindric, tapering to a point, septate, branched, about 25–50 $\times$ 2.5–3 μ, lining the beak and the somewhat elongated-ovoid cavity in the basal stroma; conidia elongate-fusiform, mostly two celled, straight or slightly curved, hyaline or pale yellowish-green, 10–20 $\times$ 2.5–3 μ, emerging in a black mass; microconidia hyaline, one celled, ellipsoid to elongated, 5–10 $\times$ 1.5–2 μ, spore masses pinkish.

TYPE: University of Toronto Herbarium *7950*. On *Nemopanthus mucronata*, Bear Island, Temagami Forest Reserve, Aug. 21, 1935. J. W. Groves and J. R. Hansbrough.

EXSICCATI (Conidial stage only): Fungi Col. *4776;* Rel. Farl *121.*

SPECIMENS EXAMINED: University of Toronto Herbarium. On *Nemopanthus mucronata. 4359, 4369, 5066, 5944, 5945, 6932, 6948, 6949, 6950, 6951, 6952, 7949, 7950,* Temagami Forest Reserve, Ontario.

University of Michigan Cryptogamic Herbarium. On *Ilex verticillata. Micropera caespitosa* (Peck), Ypsilanti, Mich., April 21, 1923. Coll. L. E. Wehmeyer. Det. W. A. Archer.

Cultures from ascospores and conidia were similar and both produced the conidial stage in culture. The fungus grew fairly rapidly on malt extract agar, spreading over the medium and forming greenish gray to almost white colonies, "pale smoke gray" to "dark greenish olive." The surface of the colonies was even, covered with a short, downy to velvety, aerial mycelium, sometimes with short, cottony tufts. Conidial fructifications formed abundantly, sometimes remaining as a small, rounded stroma which split open widely, but more often becoming elongated, cylindric-conic, up to 1.5 mm. long and 0.5 mm. in diameter, opening widely at the top, almost black or with a grayish cottony covering. The spore masses were a dark greenish black. Typical conidia and microconidia were produced and the conidia appeared to be formed successively from the same conidiophore, adhering together in chains.

On twigs of *Nemopanthus* the fungus produced a grayish aerial mycelium which was closely appressed to the twig and spread over the surface. Conidial fruiting bodies were formed only occasionally. They arose as an erumpent, rounded stroma which sometimes split open at the top, or more often elongated into a cylindric-conic beak up to 2 mm. in length, black or with a grayish or brownish mycelial covering. The structure was similar to that found in nature but sometimes the tissue was not so compact. The spore masses were characteristically black, and typical conidia and microconidia were produced.

The imperfect stage was originally described on *Ilex* by Peck (**1873**) as *Sphaeronema caespitosum.* It was said to be remarkable because of its caespitose habit of growth and its black spore

mass, and the spores were described as sub-fusiform, 11–12 μ long. Saccardo and Sydow (**1899**) pointed out that the name *Sphaeronema caespitosum* had been used previously by Fuckel for a fungus on *Acer,* and that Peck's name was, therefore, invalid. They proposed the new name *Sphaeronema Peckii.*

As found in the field *Sphaeronema Peckii* is quite distinct from *Micropera stellata* by reason of the long beaks on the pycnidia and the black spore masses. The conidia are also much smaller and of a different shape. In the original description of *Sphaeronema stellatum* the fungus was said to resemble *S. caespitosum* Peck in habit, but to differ in the spores. The statement that the two fungi resemble each other in habit was also made in Jaczewski's work which was quoted by Archer (**1926**). As stated above, the two fungi do not resemble each other in habit in the field, but the long beaks of *Sphaeronema Peckii* are very brittle and in herbarium specimens are usually broken off, and when this occurs the two fungi are not unlike in habit. *Micropera stellata* is essentially a stroma with a thick basal part and numerous cavities in the upper part, while *Sphaeronema Peckii* consists of a basal stroma from which numerous beaked pycnidia arise but with the cavities extending into the basal stroma. Thus when the beaks are broken off it appears to be a stroma with cavities in the upper part as in *Micropera stellata.*

Archer (**1926**) concluded that *Sphaeronema Peckii* was a young stage of *Micropera stellata* and combined the two forms under the name *Micropera caespitosa.* The specimen from which Archer's cultures were made was kindly loaned to the writer by Dr. Bessie B. Kanouse, and examination of this specimen has shown that while it consists mostly of *Micropera stellata,* on the same twigs there are a few fruiting bodies of *Sphaeronema Peckii* with the beaks broken off. The fungus which Archer examined and figured (1926: TEXT FIG. 13, *A, B, C, F*) is evidently *Micropera stellata,* but the fungus which he cultured is certainly *Sphaeronema Peckii.* The cultural characters and type of conidial stage produced, as described by Archer, agree with the writer's cultures of *Sphaeronema Peckii* and *Godroniopsis Nemopanthis,* but they are very different from cultures of *Micropera stellata* and *Dermatea Peckiana.* The microconidia in the two forms are strikingly dif-

ferent. In *Dermatea Peckiana* they are filiform and of the type found commonly throughout the genera *Dermatea* and *Pezicula,* but in *Godroniopsis Nemopanthis* they are ellipsoid and of quite a different form, and it is this latter type that Archer obtained in his cultures. Therefore, Archer's conclusion that *Sphaeronema Peckii* was a young stage of *Micropera stellata* is incorrect. The two fungi are quite distinct morphologically and belong to two quite different discomycetes.

The perfect stage is referred to the genus *Godroniopsis* with considerable hesitation. This genus was erected by Diehl and Cash (**1929**) based on *Peziza quernea* Schw. The genus was characterized as having apothecia which were at first closed, subspherical, later cup-shaped to patellate, with a ridged excipulum, and the paraphyses forming an epithecium. A specimen of *Godroniopsis quernea* from the herbarium of L. O. Overholts *16509* was examined. The apothecia of the two species are somewhat similar in gross appearance, shape, and manner of opening, and in both the ascospores are more or less fusiform in shape. However, while the apothecia of *Godroniopsis Nemopanthis* are longitudinally striate, they do not show the prominent excipular ridges of *G. quernea,* they are more waxy in consistency, and the paraphyses do not form an epithecium. In spite of these differences it has been decided to refer the fungus to *Godroniopsis* because it would seem to fit the characters of this genus more closely than of any other, and until more is known of the relationships of these forms it is thought to be unwise to multiply genera.

Durandiella Nemopanthis (Peck) comb. nov.

Tympanis Nemopanthis Peck, Ann. Rep. N. Y. St. Mus. **35**: 142. 1884.

Godronia Nemopanthis Sacc., Syll. Fung. **8**: 603. 1889.

Apothecia erumpent, scattered, caespitose with up to about twenty-five in a cluster, occasionally single, sessile, slightly narrowed below, up to about 1 mm. in diameter and 1.5 mm. in height, circular to very irregular in shape, closely crowded and often more or less grown together laterally so that it is very difficult to make out the outlines of individual apothecia, dull black externally, consistency hard, horny to cartilaginous, more leathery when moist, hymenium at first concave, becoming plane or convex,

dull black or sometimes shiny black, olivaceous when moist, margin at first raised, black or grayish, later almost disappearing; tissue composed of interwoven hyphae of which the walls are thickened, gelatinized, and grown together, especially at the base and toward the outside of the excipulum where the walls are very dark, but in the central and upper part of the apothecium the tissue may be looser, the hyphae more distinct and the walls not so much grown together; subhymenium a narrow, compact zone of slender, closely interwoven hyphae; asci cylindric to cylindric-clavate, with a slender stalk, eight spored, 80–125 × 7–9 μ; ascospores hyaline, filiform, septate, slightly pointed at the ends, almost straight or variously curved, lying parallel or more or less intertwined in the ascus, 50–85 × 1.5–2 μ; paraphyses hyaline, filiform, septate, branched, about 1.5–2 μ in diameter, slightly or not at all swollen at the tips, and forming a yellowish epithecium.

FIG. 3. *Durandiella Nemopanthis.* Drawings of asci, ascospores, and paraphyses. × 400.

FIGS. 4–9. 4, *Dermatea Peckiana.* Apothecia on a twig of *Ilex;* 5, *D. Peckiana.* Imperfect stage on a twig of *Nemopanthus;* 6, *D. Peckiana.* Imperfect stage on a twig of *Nemopanthus* in culture; 7, *Godroniopsis Nemopanthis.* Apothecia and imperfect stage on a twig of *Nemopanthus;* 8, *G. Nemopanthis.* Imperfect stage on a twig of *Nemopanthus* in culture; 9, *Durandiella Nemopanthis.* Apothecia on a twig of *Nemopanthus.* × 4 approx.

FIGS. 4–9.

EXSICCATI: Ellis N. Am. Fungi *2330;* Fungi Col. *4539.*

SPECIMENS EXAMINED: Type. Durand Herbarium *3023.* On *Nemopanthus canadensis* (*N. mucronata*), Grafton, Reno Co., N. Y. Coll. Dr. Peck.

University of Toronto Herbarium. On *Nemopanthus mucronata. 3515, 5067, 5068, 6567, 6583, 7940,* Temagami Forest Reserve, Ontario—*4840,* Ottawa, Ontario—*6936,* Bell's Lake, north of Parry Sound, Ontario—*7941,* south of Hatchley, Ontario.

Farlow Herbarium, Harvard University. On *Nemopanthus canadensis,* Fort Ethan Allen, Vt., Coll. E. A. Burt, July 1896. Det. Peck. Ex. Burt Herbarium.

On malt extract agar the colonies from ascospores grew slowly forming greenish-gray to yellowish or sometimes brownish colonies. The margin was even and almost colourless and the rest of the colony was covered with a short, even, velvety, aerial mycelium, the surface appearing smooth. Sometimes more or less unevenly rounded to columnar stromatic structures developed which might be up to 5 mm. in diameter and 2 mm. in height. Colourless or amber drops of liquid appeared on them and they later developed flat, black, disc-like areas on the top and sides. The tissue resembled somewhat the basal part of the apothecial stroma in structure but no spores of any kind have been produced.

On twigs of *Nemopanthus* the fungus produced a velvety, gray, aerial mycelium which was closely appressed to the twig and most abundant near the point of inoculation but sometimes spread over the whole twig. No fruiting bodies of any kind have been produced.

Careful search in the field has failed to reveal any conidial stage associated with the apothecia.

This fungus was originally described on *Nemopanthus* by Peck (**1882**) as *Tympanis Nemopanthis,* and later transferred to *Godronia* by Saccardo (**1889**) because of the filiform ascospores. Rehm (**1913**) erected the genus *Durandia,* based on *Tympanis Fraxini* (Schw.) Fries and the genus was characterized as having apothecia like a *Tympanis* and ascospores like a *Godronia.* This fungus on *Nemopanthus* would seem to be congeneric with *Durandia Fraxini* (Schw.) Rehm.

Von Höhnel (**1918**) pointed out that the name *Durandia* was invalid, having been used previously for a genus of flowering plants. He was of the opinion that *Tympanis Fraxini* belonged in *Godronia*, largely because of the character of the imperfect stage and the filiform ascospores. Nannfeldt (**1932**) accepted Von Höhnel's interpretation and included *Durandia* Rehm and *Godronia* Moug. as synonyms of *Scleroderris* Fries. Seaver (**1932**) proposed the new name *Durandiella* to replace the invalid name *Durandia*.

The writer, as a result of his studies in this group, is of the opinion that a separation between the black, patellate forms and the urceolate forms having filiform ascospores is desirable, and that, therefore, *Durandiella* Seaver should be recognized as distinct from *Scleroderris* or *Godronia*.

SUMMARY

Three species of discomycetes of the family Dermateaceae have been distinguished on *Nemopanthus* and their conidial relations established by cultures.

1. *Dermatea Peckiana* (Peck) Groves of which the imperfect stage is *Micropera stellata* (Ellis) Jaczewski.

2. *Godroniopsis Nemopanthis* Groves of which the imperfect stage is *Sphaeronema Peckii* Saccardo and Sydow.

3. *Durandiella Nemopanthis* (Peck) Groves of which no imperfect stage has been found.

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A NEW SPECIES OF PHIALEA ON ALDER SEEDS

J. R. KIENHOLZ AND EDITH K. CASH [1]

(WITH 4 FIGURES)

Two interesting Discomycetes were collected in the spring of 1932 in the Hood River Valley, Oregon, under alder trees. Little difference was apparent when they were observed superficially, but closer examination revealed that their seat of origin was entirely distinct. The one, arising from alder catkins, was kindly identified by H. H. Whetzel and F. J. Seaver as *Ciboria amentacea* (Balb.) Fuckel. The second, developing from overwintering seeds of the same host, appears to be undescribed and will be dealt with here.

Collections of this fungus have been made each year since its discovery. It has usually been found associated with the species of *Ciboria* referred to and so far only on seeds of *Alnus oregona* Nuttall. An extensive survey has not been made but the fungus appears to be common throughout the Hood River Valley, Oregon, at elevations ranging from 100 to 3000 feet. It matures at the time when alder catkins begin shedding pollen and disappears in a short time. Occasionally numerous apothecia have been found developing from infected seeds still held within the cones (FIG. 1). Both fungi were scarce during the spring of 1936, probably due to an unusually dry summer season in 1935, followed by early freezing weather.

The genera *Alnus* and *Salix* are hosts for several species of *Phialea*. Comparisons of available specimens and published descriptions, however, have failed to reveal a species to which our fungus can be referred. *Phialea alniella* (Nyl.) Sacc., *P. amenti* (Batsch.) Quél., and *P. viridifusca* (Fuckel) Sacc. appear to be

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its closest relatives, all of which occur on catkins. The larger size of the apothecia and their development from alder seeds are macroscopic characters which easily distinguish our fungus from them. The longer and wider asci and ascospores, and certain other features described below, serve further to separate this species of *Phialea* from others occurring on *Alnus* or related plants. The species name *seminicola* has been selected as being descriptive of the seed-inhabiting character of this new species.

Phialea seminicola sp. nov.

Apothecia stipitate, waxy-membranous, single or 2–5 arising from a seed, cupulate with inrolled margin, finally expanded and often flattened above, up to 6 mm. diam., commonly Tilleul-buff to avellaneous, hymenium fawn-color or somewhat variable, paler when old or dry; hypothecium composed of loosely arranged, irregularly elongated, pale brown cells; excipular cells several layers thick, thin-walled, pale brown, irregularly spheroid, up to 25 μ diam., merging into the elongated cells of the stem; stem up to 10 mm. long, usually less, 0.5–0.8 mm. diam., sometimes swollen and hairy toward the base when young, becoming even and often darker when older; asci clavate, thick-walled at apex, short-pedicellate, 75–130 $\times$ 7.5–12.5 μ (mean 104 $\times$ 9.9 μ), uncolored by iodine; paraphyses granulose, filiform, simple or branched below the middle, slightly enlarged up to 4 μ at apex, hyaline; spores unicellular, fusoid-ellipsoid with somewhat pointed ends, containing 1-several small guttules toward each end, hyaline, 12–20 $\times$ 3.5–5 μ (mean 15.8 $\times$ 4.9 μ), 1- or irregularly 2-seriate.

Ascomatibus stipitatis, ceraceo-membranaceis, avellaneis, 1–5 ex quoque semine oriundis, cupulatis margine incurvato, dein applanatis, usque ad 6 mm. diam., hypothecio prosenchymatico, ex cellulis elongatis, fuscidulis, laxe intertextis, excipulo ex stratis nonnullis cellularum subglobosarum tenellarum compositis; stipite usque ad 10 mm. longo, .5–.8 mm. diam., pruinoso vel glabro; ascis clavatis, apice crasse tunicatis, breve pedicellatis, 75–130 $\times$ 7.5–12.5 μ; paraphysibus filiformibus, hyalinis, granulosis, apice 4 μ diam.; sporis unicellularibus, fusoideo-ellipsoideis, ad extremitates guttulatis, hyalinis, 12–20 $\times$ 3.5–5 μ, 1–2-seriatis.

In seminibus *Alni oregonae*, in vere, Hood River, Oregon.

FIG. 1, apothecia $\times$ 1; 2, apothecia $\times$ 15, showing pubescent stipe; 3, camera lucida drawing of a portion of an apothecium showing structural characters; 4, camera lucida drawings of asci, ascospores, and paraphyses. (Photographs and drawings by J. R. Kienholz.)

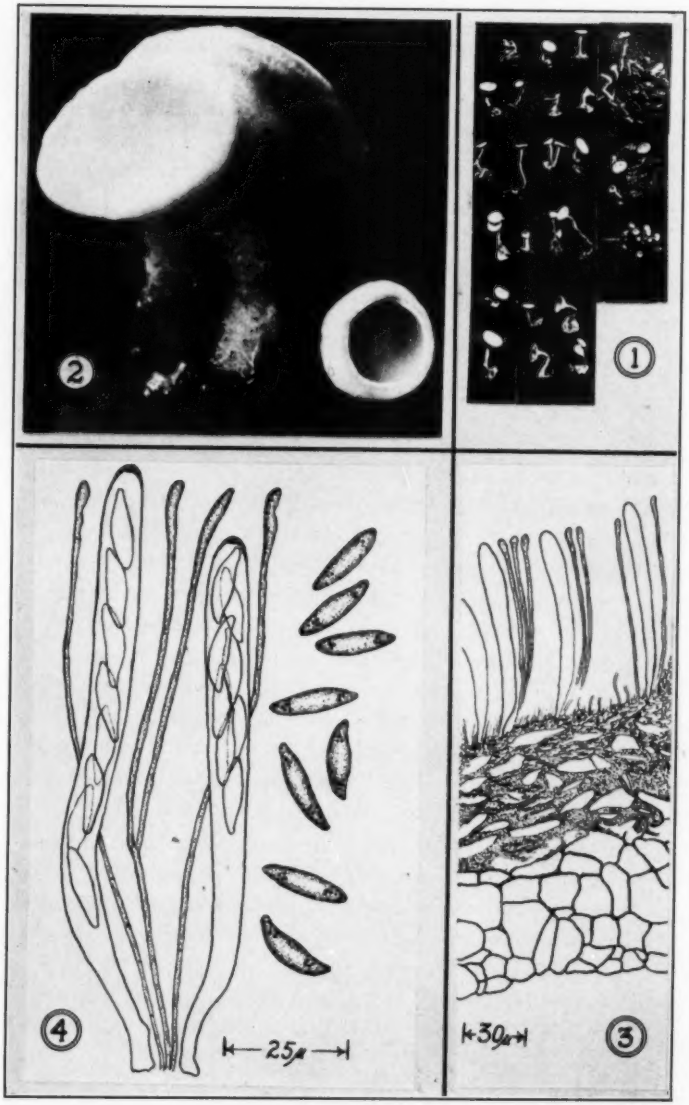

FIG. 1–4.

Developing from alder (*Alnus oregona* Nuttall) seeds, Hood River, Oregon, in early spring, coll. J. R. Kienholz, 1932–1936. Type *K 10,* February, 1935.

Type specimens have been deposited in the Mycological Collections of the Bureau of Plant Industry, U. S. Department of Agriculture, and Department of Botany, Oregon State College, Corvallis, Oregon. Collections from the type locality have also been distributed to the Mycological Herbaria of the following institutions: New York Botanical Garden, Cornell University, University of Michigan, and Washington State College.

BUREAU OF PLANT INDUSTRY

NATURE OF VARIATION IN HELMINTHOSPORIUM SATIVUM [1]

J. J. Christensen and F. R. Davies [2]

(with 3 figures)

INTRODUCTION

Most species of *Helminthosporium* that have been carefully investigated comprise numerous races differing in parasitic capabilities, cultural characters, and to some extent in morphology. This is particularly true of *Helminthosporium sativum* P.K.B., in which new races frequently arise as sectors in cultures on artificial media. The mechanism by which these variants arise is not definitely known, but it is usually attributed to mutation.

Genetic changes in fungi may result from hybridization and subsequent segregation, by mutation or saltation, and possibly as a result of heterocaryosis. Although hybridization is very common in some fungi and results in the production of new types, it apparently does not play an important rôle in *Helminthosporium sativum*, the perfect stage of which has been described as *Ophiobolus sativus* (P.K.B.) Ito and Kuribayaski (**10**). Since 1920 the authors have made numerous attempts to induce the formation of the sexual stage, but without success. Mutation, as a mechanism for the production of new races, has been demonstrated in fungi, particularly in haploid lines of smut fungi. Mutation in *Helminthosporium* spp. also has been frequently reported, but some investigators have objected to the term chiefly because the cells of the hyphae, conidia, and germ tubes are usually multinucleate. The variants then might be due to the separation or reassortment of nuclei.

[1] Paper No. 1438 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station. The investigations were supported in part by a grant from the Graduate School of the University of Minnesota.

[2] The writers are greatly indebted to Professor E. C. Stakman for his criticism and help in the preparation of the manuscript.

Recent work by Hansen and Smith (**8**), Graham (**6**), and Shands and Dickson (**12**) has suggested that heterocaryosis may be rather common in the Fungi Imperfecti and hence may account for many of the variants that arise so abundantly in culture. More recently Hansen (**7**) has reported heterocaryosis in isolates representing twenty-eight strains, twelve species, and seven genera in three orders of the Fungi Imperfecti. Leonian (**11**) attempted to produce a mixochimaera in *Fusarium moniliforme* Shel. in culture but was unsuccessful. From his studies on the nature of variation in certain species of *Fusarium* and *Helminthosporium*, Dickinson (**4**) concluded that the variants were not due to heterocaryosis or to cytoplasmic inheritance but rather to saltation. However, he did find that hyphal cells of different strains of *Fusarium* sp. would fuse, and in three cases both of the original strains were isolated from cultures resulting from hyphae growing out from the fused cells. This indicates that nuclei of the two strains were temporarily associated in the hyphal cells but that they soon separated again.

The present investigation was undertaken in an attempt to elucidate the nature of the variation that occurs so commonly in *Helminthosporium sativum* and certain other dark-spored species of this genus. Particularly, the writers attempted to ascertain if there was a tendency for two genetically different nuclei to become associated in the vegetative stage and for this association to persist through the conidia. A preliminary paper on this work has been published (**3**).

EXPERIMENTAL METHODS

Hyphal anastomosis.

Many workers have observed hyphal fusions between different races within species of Fungi Imperfecti, and Dickinson (**4**) observed fusions between different species of *Helminthosporium*. Obviously, the occurrence and extent of hyphal anastomosis is of primary importance in a study of heterocaryosis. The writers therefore studied fusions between hyphae of the same species and between those of different dark-spored species of *Helminthosporium*. In all, fusion tests were made between thirteen different combinations, involving seven races and four variants of *Helmin-*

thosporium sativum, two races of *Helminthosporium N* (see Henry (**9**)), and one race of *H. tetramera* McKinney.

The tests were made in three ways: (1) by mixing conidia and mycelia on glass slides smeared with nutrient agar and then incubating for one to two days in a moist chamber; (2) by planting

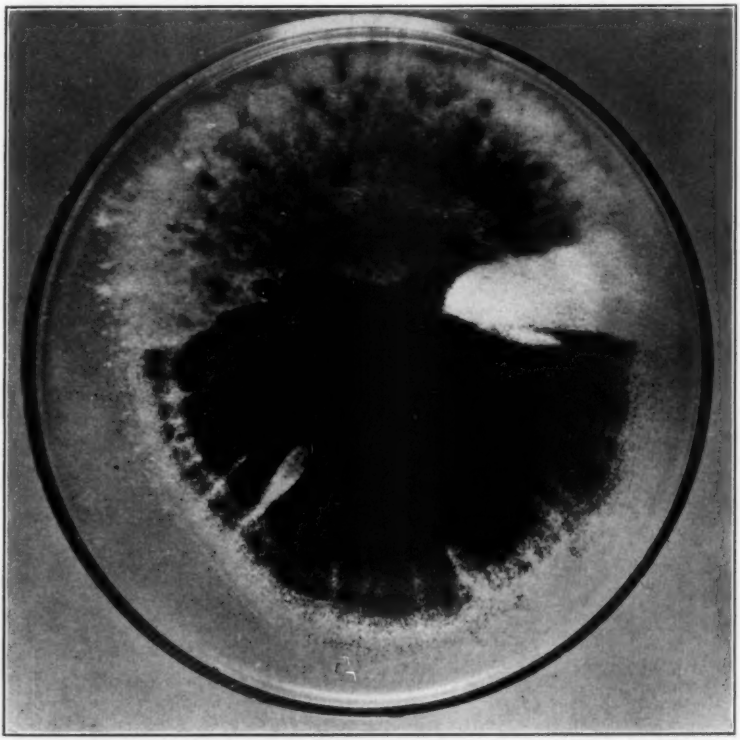

FIG. 1. *Helminthosporium sativum* race 1 giving rise to variants on bacterial-staled medium. Race 1 has been cultured for 17 years, transferred several hundred times, and single spored four successive times.

a mixture of spores on agar drops on cover slips; and (3) by planting spores of two races on separate agar drops placed about 5 mm. apart on cover slips and observing the hyphal fusions on the plain glass between the drops. In some cases the process of fusion was observed more or less continuously for periods up to

one hour, whereas many were only observed after the fusion had taken place.

Within the same species of *Helminthosporium* fusions usually were abundant, but between species true fusions (cell walls completely broken down) were rarely observed. However, pseudo fusions (hyphal union, but cell walls not broken down) designated by Buller (**1**) as "hyphal adhesion" between species of *Helminthosporium* were very common. In fact, in several tests this type of fusion was so abundant between *H. sativum* and a small-spored species (Brachysporium type, race 8) and also between *H. sativum* and *Helminthosporium N* race 3 that the hyphae of the two species appeared to be united to form a network.

The origin of the nuclei in conidia of *Helminthosporium* is of considerable importance in a study of variation. Several investigators have noted that conidia, hyphal cells, and germ tubes of *Helminthosporium* spp. are usually multinucleate (**4**, **6**). Nuclear stains were made of *Helminthosporium sativum, Helminthosporium N, H. tetramera,* and a *Brachysporium* type, using the ordinary cytological technic. The spores were germinated on glass slides, incubated for one to two days, then fixed in weak chromo-acetic, and stained with Haidenhain's iron-alum haematoxylin. In the four species studied the number of nuclei in the hyphal cells varied from one to six, one and two being the most common. Germ tubes were always multinucleate, probably due to a more rapid nuclear division than cell wall formation. Young branches from the older hyphae and young conidiophores often contained a single nucleus, which supports Dickinson's observations (**4**). If this is true, all nuclei in the spores produced on the same conidiophore are derivatives of a single nucleus and should therefore be of the same genotype, assuming normal mitosis. Graham (**6**), on the other hand, obtained indications that the nuclei in conidia of *H. gramineum* Rab. (a light-spored type) were not derived from a single nucleus, and Hansen and Smith (**8**) concluded that conidia of *Botrytis cinerea* Pers. may contain genetically different nuclei.

Hyphal-tip cultures.

Eide (**5**) and Ullstrup (**14**) found that hyphal-tip cultures from the same germinating ascospore or conidium of *Gibberella Saubi-*

netii (Mont.) Sacc. were always alike. Shands and Dickson (**12**), however, found that hyphal-tip isolates of *Helminthosporium gramineum* from the same germinating conidium might differ in cultural and parasitic behavior. In order to obtain evidence by cultural methods regarding the possible heterocaryotic condition of conidia of *H. sativum*, single spores from mixed races growing in combination and also from sectoring cultures were germinated

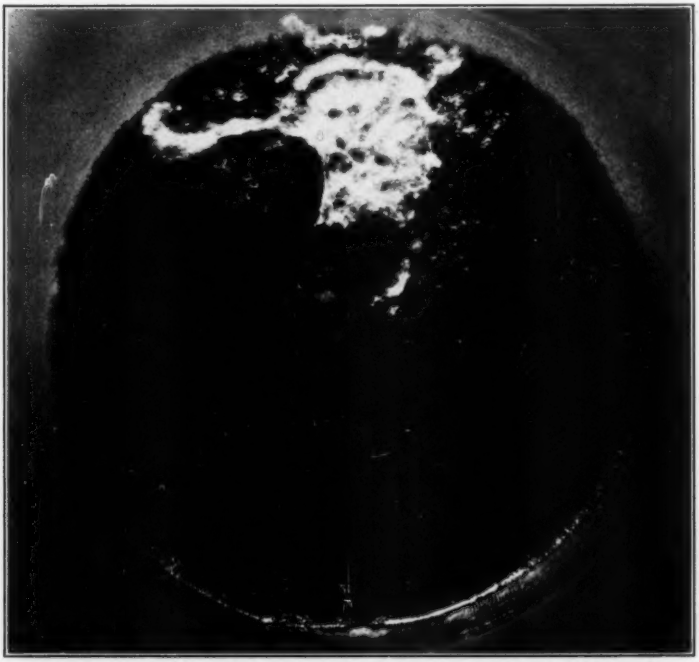

FIG. 2. *Helminthosporium N* race 3 giving rise to a "patch" variant.

on agar drops from which one to four hyphal tips were isolated. The tips usually were cut from a germ tube after it had produced two or three short branches, although some were cut off before the branches developed. Many of the hyphal tips consisting of a single cell died; but they grew well if they consisted of two or more cells. In each case the germinating spore (spore and the basal cells from which the hyphal tips had been cut) also was isolated.

In all, 207 hyphal-tip isolates were made from 103 germinating conidia. In one series, 41 conidia were selected from sectoring monosporous cultures of five distinctly different races of *Helminthosporium sativum* (FIG. 1). If variation in this series were due to heterocaryosis, conidia selected from the parental part of the colonies should contain genetically different nuclei, and there would be a likelihood that hyphal tips from the same conidium might be different because of the chance assortment of nuclei. With one possible exception, however, all the isolates (including hyphal tips and the spore and its basal cells from which the hyphal tips had been cut) from the same conidium were identical. In preliminary tests, one hyphal-tip isolate was distinctly different from the other hyphal-tip cultures from the same germinating conidium. Examination of the test-tube culture showed the presence of two kinds of growth, one true to type, the other apparently similar to a variant commonly produced in the parental culture; hence the variant probably arose in the test-tube culture as a mutation rather than as a result of dissociation of nuclei in the germ tube.

Another series of 141 hyphal tips, also included in table 1, was cut from 62 germinating conidia obtained from mixtures of dis-

TABLE 1

SUMMARY OF HYPHAL-TIP ISOLATIONS FROM GERMINATING CONIDIA OF HELMINTHOSPORIUM SATIVUM

Source and race or variant of *H. sativum*	Number of conidia	Number of hyphal tips per conidium isolated				Total number of isolates [a]
		1	2	3	4	
Sectoring monosporous cultures						
1	9	2	5	2	0	18
16	2	2	0	0	0	2
31	9	2	4	3	0	19
32	12	4	4	4	0	24
33	9	9	0	0	0	9
Mixture of two races or variants on agar drops						
1 and 32	32	13	10	5	4	64
1 and 1–3 [b]	8	2	2	2	2	20
40 and 1–4	22	7	5	6	4	51
Totals	103	41	30	22	10	207

[a] In each case the germinating spore (spore and the basal cells from which the hyphal tips had been cut) was isolated also.

[b] Variants are indicated by a (−) sign following the race number.

tinct races or variants of *Helminthosporium sativum* growing on agar drops. Three different mixtures of races of *H. sativum* were made. Without exception the isolates, including the germinating spore with its basal cells and the hyphal tips derived from it, were identical.

Conidiophore progenies.

Having found no definite evidence for differences in any of the hyphal-tip isolates arising from single spores, it was considered possible that only a single nucleus passes into each spore, so that all nuclei in a spore would be genetically alike, assuming normal mitosis. Therefore, it seemed advisable to analyze the conidial progenies of individual conidiophores.

Conidia from individual conidiophores were taken from colonies arising from barley seed, either naturally or artificially inoculated with many races and species of Helminthosporium or from a mixed growth of two distinct races or species on agar drops. Comparisons of the progeny from the same conidiophore were made on potato-dextrose agar, first in a preliminary way in test tubes and then in petri dishes. Table 2 lists the isolations from naturally

TABLE 2

SUMMARY OF CONIDIAL ISOLATIONS FROM INDIVIDUAL CONIDIOPHORES OF CULTURES OBTAINED FROM INFECTED SEED

Source of barley seed	Number of conidiophores	Number of spores per conidiophore isolated				Number of isolates
		2	3	4	5 or more	
Naturally infected	29	29	0	0	0	58
Artificially inoculated with a combination of races	69	32	14	14	9	208
Total	98	61	14	14	9	266

and artificially infected barley seed. A total of 266 conidia were isolated; 58 from naturally infected seed and 208 from artificially infected seed representing progenies from 98 conidiophores. In most cases isolations were made as soon as sporulation started, so that if a heterocaryotic condition existed the chances for migration of different kinds of nuclei into different conidiophores might be greater in the earlier stages of growth, especially if the nuclear

associations were only temporary. With two exceptions, no variations were observed between cultures from conidia produced on the same conidiophore. The two variant cultures differed very slightly but consistently from other isolates from the same conidiophore. Several single spores were isolated from one of these variants, and still other variants arose in the cultures.

The races and variants used in combination cultures were selected because of easily recognizable contrasting characters. It is rather significant that the 258 monosporous isolates from 107 conidiophores selected from 10 different combinations of races were not affected by the association and also that single-spore cultures from the same conidiophore were without exception identical (Table 3). Furthermore, 260 conidia were selected at ran-

TABLE 3

MONOSPOROUS ISOLATIONS FROM INDIVIDUAL CONIDIOPHORES FROM COMBINATIONS OF RACES OF HELMINTHOSPORIUM SPP. GROWN ON AGAR DROPS

Race and species of *Helminthosporium*	Number of conidiophores	Number of spores per conidiophore isolated				Number of isolates
		2	3	4	5 or more	
H. sativum						
1 and 40–1	17	10	6	1	—	42
1 and 32	12	12	—	—	—	24
1 and 33	1	1	—	—	—	2
40–1 and 1–1–1–4	9	9	—	—	—	18
40–1 and 14	4	4	—	—	—	8
40–1 and 15	12	12	—	—	—	24
31 and 32	18	12	4	1	1	45
32 and 33	2	2	—	—	—	4
14 and 1–3	23	23	—	—	—	46
Helminthosporium N						
1 and 3	9	0	2	3	4	45
Total	107	85	12	5	5	258

dom from five different combinations of races on agar drops, and in all cases only the parental cultures were reisolated. Moreover, numerous conidiophores from various sources were cultured, and in every case they were identical to the conidial progeny isolated from them. This indicates that the nuclear condition in the conidia was the same as in the conidiophores.

Variations.

Although all hyphal-tip progenies from the same germinating conidium and virtually all conidial progenies from the same conidiophore were identical culturally, under certain conditions most of them sectored and gave rise to many variants. Variants arose either in patches or fan shaped sectors. A " patch " variant may arise in young or in older cultures; it may remain small, tufted, or blotch like, or it may grow over the entire surface of the parent colony. Figure 2 shows a " patch " variant in *Helminthosporium N* race 3. Such variants are likely to be overlooked, especially when they occur in test-tube cultures, and thus may account for many unstable cultures.

Some of the hyphal-tip or conidial isolates occasionally gave rise to distinct sectors, indicating their potential ability to produce variants. Obviously, the extent and frequency of the variation in isolates obtained in these studies are highly significant. It is well known that environmental factors have a marked effect on the frequency of variation in fungi. In order to induce variation many different substances were added to nutrient media, but none proved entirely satisfactory. Recently, it was found that the addition of 50 to 100 cc. of a certain dead bacterial culture to one liter of ordinary potato-dextrose agar increased the frequency and also the kind of variations produced.[3] On this bacterial-staled medium most of the isolates of *Helminthosporium sativum* developed from 2 to 5 variants per colony and some produced many more, 10 to 20 per colony being not uncommon. For instance, duplicate colonies from 10 hyphal-tip cultures isolated from 5 different germinating conidia of a mixed culture (races 1 and 32) gave rise to more than 300 sectors, an average of 15 per plate. In similar tests 60 monosporous isolates gave rise to 193 variants. Race 1 deserves particular mention, for it has been in culture for 17 years, transferred several hundred times, and single spored four successive times. As far as can be ascertained, it is identical with the original isolate in cultural characters and in parasitic capabilities. Furthermore, in 1925 (see (2), plate 9) and on several occasions in recent years numerous single spores

[3] This work will be reported in detail at a later date.

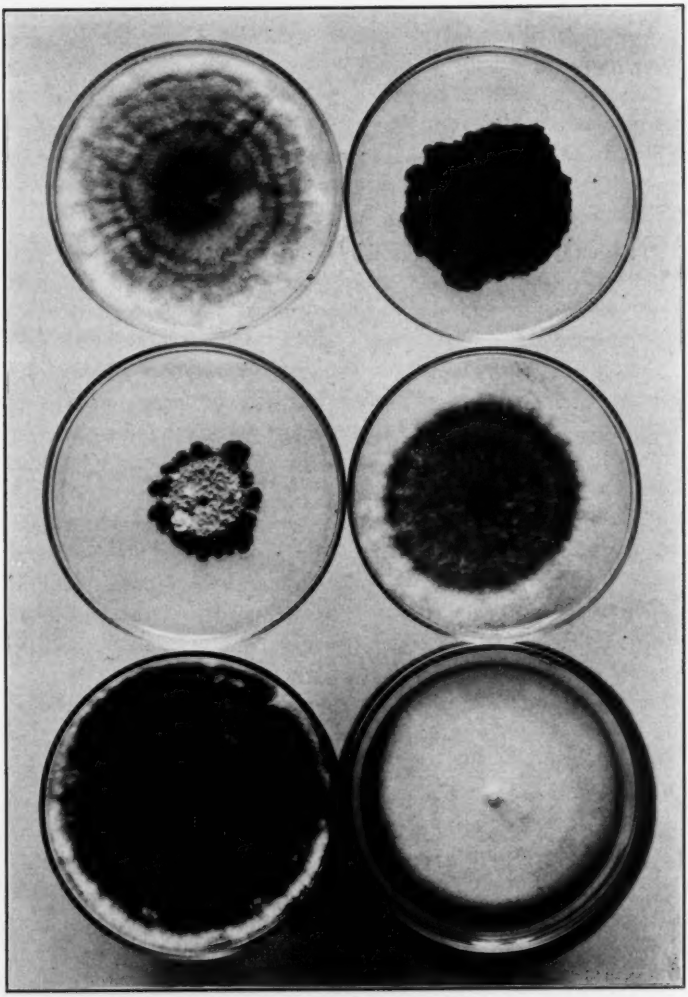

FIG. 3. Parent (lower left) and five variants of *Helminthosporium sativum*. The parent had been cultured for 17 years, and the variants appeared in cultures on bacterial-staled agar.

were selected at random from it, but in all cases the monosporous isolates and the parental culture were identical. However, race 1 has occasionally produced variants in the form of sectors, but even more important is the fact that it still gives rise to variants, especially when grown on the bacterial-staled nutrient medium (FIG. 1 and 3). For instance, within the last year at least 26 distinct variants have been isolated from it, many of which sectored again. In a preliminary test quadruplicate colonies developed 20 distinct sectors, and 4 other colonies growing on a somewhat greater concentration of the staled medium developed so many sectors and "patch" variants that their identity and number could not be definitely ascertained, while the 4 control colonies on standard potato-dextrose agar did not sector. In later tests, involving 17 colonies on the bacterial-staled medium, 81 variants occurred representing many distinct types. It is significant that one or more variants arose in nearly every colony on staled medium, while there were none in 17 control colonies on standard potato-dextrose agar.

These results indicate further that variation at least in certain races of *Helminthosporium sativum* can be induced by certain environmental factors and is probably due primarily to changes within the nucleus, rather than to heterocaryosis.

DISCUSSION

Hyphal-tip and monosporous cultures of *Helminthosporium sativum* produced numerous variants of different kinds, but the nature of this variation is not definitely known. Anastomosis between hyphal cells of different races was very common, and it is reasonable to assume that there was a certain amount of mixing of cytoplasm and nuclei. However, no immediate growth expression of the mixture of two races was observed, and if intermixing of nuclei occurred there was no indication that the association of nuclei was perpetuated through the spore to dissociate at a later time. Monosporous isolates taken from agar drops or host tissue inoculated with two races or species of *Helminthosporium* were, with three exceptions, always identical to one or the other of the parents, and new or intermediate types were never observed. Subsequent single-spore isolation from the three exceptions did not

result in isolates identical to either of the original components; hence they probably arose in the test tubes as "patch" variants, which is not uncommon in certain races of *Helminthosporium*. Other possibilities are that the change may have occurred in either the conidiophore or in the conidium.

In some fungi following hyphal fusion with subsequent intermingling of nuclei between two races, there is often a marked growth response in culture and often a pronounced change in parasitism. However, in several hundred tests with *Helminthosporium sativum* no variation in growth character was observed when colonies of different races were grown side by side in a petri dish.

In cultures of certain heterothallic and homothallic fungi whose hyphal cells are dicaryotic or multinucleate there may arise unisexual conidia or areas of unisexual mycelium, indicating that the conjugate nuclei may sometimes separate. Presumably nuclei that are not held together by sexual attraction would separate more easily than those that are. As there is no evidence that the nuclei in the cells of *Helminthosporium* are bound by sexual attraction, it would be expected that they would separate more readily than those of dicaryons. If, then, the nuclei in cells of *Helminthosporium sativum* are genetically different, one would expect that there might occasionally be a chance assortment in the different germ tubes from a single conidium, and cultures resulting from the different hyphal tips should be different. But analysis of progenies from individual conidiophores and of hyphal tips from germinating conidia indicates that nuclear changes or dissociations rarely occur in conidiophores even when taken from mixed cultures of two races. Conidia and germ tubes of many fungi including *H. sativum* are multinucleate, but this is no guarantee that they contain genetically different nuclei, since all the nuclei may be derivatives of the same nucleus. Cytological studies indicate that most young conidiophores of *H. sativum* are uninucleate; hence nuclei in the conidia produced on them are derived from the same nucleus. Extensive cultural studies of progenies of conidiophores support this statement.

Stakman and his co-workers have shown that variations are common in haploid lines of smut fungi. These lines originated

from single uninucleate sporidia, yet a single line of *Ustilago Zeae* (Beck.) Ung. gave rise to more than 150 different cultural types of variants (**13**). If mutation occurs in some fungi, there can be no valid reason why it should not occur in *Helminthosporium sativum*. In the present studies there was no indication that the growing together of two or more races of *H. sativum*, either on agar or in the host, stimulated the production of variants. Isolates from mixed cultures sectored no more frequently than the original races, some of which had been in culture for many years. In fact, one race had been cultured for 17 years, during which time it had been single spored four times, yet it still gives rise to numerous variants of different types.

Heterocaryosis, in the sense of a heterothallic fungus containing two kinds of genetically different nuclei, is a common phenomenon in both Ascomycetes and Basidiomycetes. It has been shown that such fungi may give rise to three very distinct types, *i.e.*, two different haploid strains and a dicaryotic strain. By analogy, it seems reasonable to assume that certain members of the Fungi Imperfecti may also produce three different strains. Although the evidence presented strongly indicates that the variation encountered in *Helminthosporium sativum* is due primarily to mutation (gene change or chromosomal aberration), the possibility of heterocaryosis is not excluded. Heterocaryosis may be a common cause of variation in certain other species of *Helminthosporium* and also in other fungi, but it is not considered an important cause of variation in *H. sativum*.

SUMMARY

1. The conidia and germ tubes of *Helminthosporium sativum* are multinucleate, whereas hyphal cells are uninucleate to multinucleate, and young conidiophores are usually uninucleate. All nuclei in the conidia produced on the same conidiophore are perhaps derivatives of a single nucleus and hence genetically alike.

2. True hyphal fusion between races of *H. sativum* is common but rare between *H. sativum* and other dark-spored species. However, pseudo-hyphal fusion between species of *Helminthosporium* is not uncommon.

3. Cultural comparisons were made of 207 hyphal-tip isolates obtained from 103 germinating conidia taken from colonies giving rise to variants or from mixed colonies on agar drops. All the isolates from a single conidium were identical with the original culture.

4. Cultural comparisons were made of 524 conidial isolates obtained from 205 individual conidiophores taken from mixtures of 2 distinct races or species growing on agar drops or from colonies derived from barley tissues infected with 2 or more distinct races or species of *Helminthosporium*. All the isolates from the same conidiophore, with two exceptions, were identical culturally.

5. Variants occur frequently in *Helminthosporium* spp. either in the form of sectors or "patches." Although *H. sativum* race 1 has been cultured for 17 years, it still gives rise, under certain conditions, to numerous variants of different types.

6. Potato-dextrose agar rendered stale by certain bacteria was found conducive to the development of variants.

7. The results indicate that genetic variation in *H. sativum* is caused primarily by nuclear change rather than by heterocaryosis.

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CYTOLOGICAL STUDIES IN THE TREMELLACEAE. IV.[1] PROTODONTIA AND TREMELLODENDRON

R. M. WHELDEN

(WITH 2 FIGURES)

In every group of organisms there occur members which differ so strikingly from the common nature of the group as to arouse one's interest. The Tremellaceous fungi are no exception to this statement, for in this family one finds the effuse *Protodontia* with its surface thickly studded with the short teeth which give it its name, and the earth-dwelling *Tremellodendron* with its erect much-branched fruit-bodies so like those of certain species of *Clavaria*.

An examination of the literature on the cytology of fungi reveals very little dealing with either of the fungi considered in the present paper. *Tremellodendron* seems to be entirely untouched, while *Protodontia* fares little better; in fact, unless one considers Kühner's *Protohydnum lividum* Bres. (1) to be a *Protodontia*, one can report again that no work has been done. But as Martin (2) has pointed out, *Protohydnum lividum* Bres. may well be a *Protodontia*, so it seems well to consider briefly Kühner's results. He found the basidium initial to contain two nuclei whose early union formed the fusion nucleus. The latter rapidly enlarged in the swelling basidium, and developed a very definite chromatin content. The first division spindle was conspicuously transverse in the basidium; on it the chromosomes were confusedly clumped, and indeterminate in number. A second division followed. Four short, widely separated epibasidia developed and bore distally each a single spore which received a single nucleus. The spore readily germinated by a short slender tube through which the single nucleus migrated without dividing. Kühner's observations on this fungus were not extensive, and did not include any

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 146.

particular details as to the progressive changes which took place. Whether Kühner's fungus was the same as the *Protodontia* here studied, the writer is not prepared to state. Suffice it here that the writer's determination of his fungus as *Protodontia uda* v. Höhnel has since been independently verified by Dr. D. P. Rogers, who has compared it with the type specimen and finds it to agree therewith exactly. In earlier papers (**3**) the writer has described in detail various changes in the life-history and cytology of the genera of Tremellaceae more commonly found in this region, pointing out particularly the details observed in the nuclei in various parts of the fruit-body. The present paper treats in similar fashion two more members of the family, which, though showing in their cytology details quite similar not only to the genera previously studied but also to each other, yet are so different in appearance and in several particulars as to justify separate treatment.

PROTODONTIA UDA V. HÖHNEL

The habit of this fungus has been sufficiently described above, so that one may pass directly to a consideration of its component parts. Of these the first to appear is the mycelium, composed of an inconspicuous weft of slender hyphae, penetrating for short distances into the substratum, but more conspicuous in forming a thin layer of loosely aggregated intertangled hyphae extending over the substratum. The hyphae in this region extend parallel to the substratum, have a very thin inconspicuous layer of cytoplasm, and contain minute nuclei somewhat irregularly scattered in the very long segments (FIG. 1: 1). On approaching the surface of the fruit-body, the hyphae become slightly larger in diameter, acquire a denser cytoplasm and more evident but still very small nuclei which tend to become rather numerous in the hyphal tips (FIG. 1: 4, 5). Branching occurs frequently and rather irregularly, with the nuclei very irregularly distributed therein (FIG. 1: 2, 3); this branching is particularly abundant in the teeth. In the various parts of the mycelium, but especially near the hyphal tips, nuclear divisions occur abundantly. The small size of the nucleus makes it very difficult to observe exactly any details of the process. It is, however, fairly evident that four very minute chromosomes are formed in each nucleus during division. No

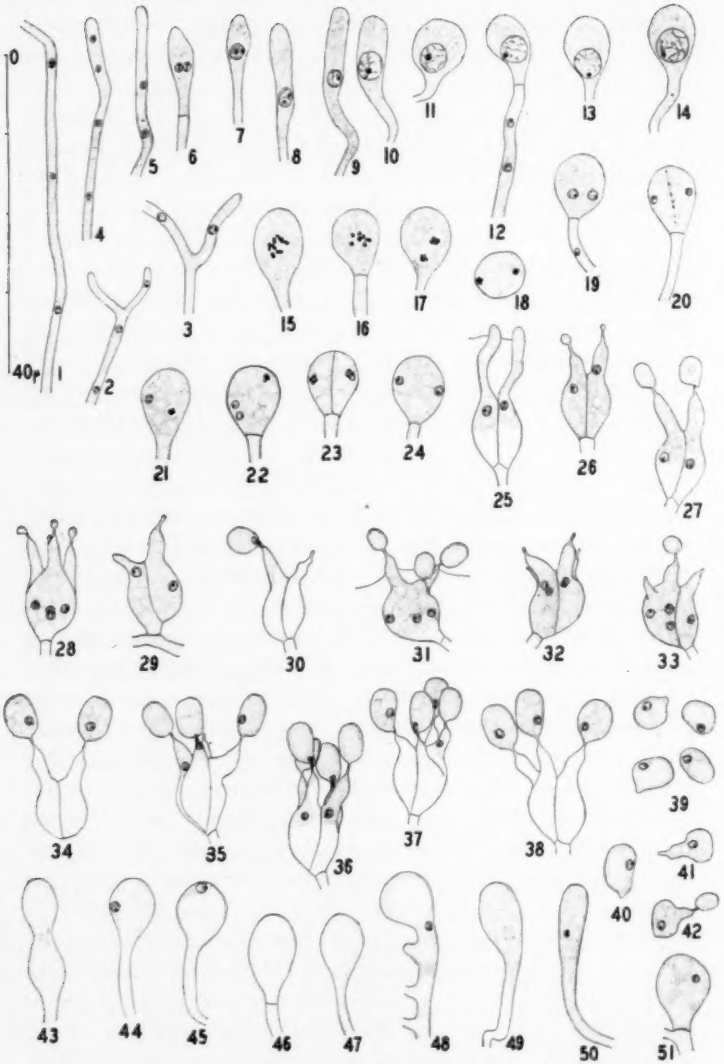

FIG. 1. *Protodontia uda.*

clamp connections were seen in any part of the mycelium. The presence of abundant moisture, by swelling the "jelly" surrounding the hyphae, separates them, making observation easier.

Basidium. Many hyphal tips, both in the surface of the projecting teeth and in the flat portion between these, are distinguished by their increasingly dense cytoplasm and by the presence therein of the two closely associated nuclei. These, the hypobasidium initials (FIG. 1: 6), slowly enlarge in diameter, sometimes becoming fusiform (FIG. 1: 7) in shape, but more often long cylindrical (FIG. 1: 8–10). With enlargement occurs fusion of the two small closely associated nuclei. After fusion of the two associated nuclei, the resulting nucleus enlarges, as does also the hypobasidium. It is worthy of notice that in this fungus the fusion nucleus becomes quite conspicuously swollen before any striking enlargement of the hypobasidium has taken place (FIG. 1: 10). Furthermore this enlarging fusion nucleus constantly remains quite remote from the apex of the hypobasidium. As the nucleus nears its maximum size, the basidium begins rapidly to enlarge to a shape approximately spherical, and often with a considerable stalk above the basal septum (FIG. 1: 11–14). At times the basal septum forms simultaneously with the fusion of the two nuclei, and at others its formation is delayed until the division of the enlarged fusion nucleus is nearly completed. The mature hypobasidium is a subspherical to short ellipsoidal body 7–8 μ in diameter, containing a fusion nucleus 3.7–4 μ in diameter and almost invariably situated at the very base of the enlarged portion. Throughout its existence, the fusion nucleus has contained a very evident but minute nucleolus which only disappears at the time when the chromosomes become distinct. More difficult to determine is the exact nature of the chromatin in the fusion nucleus: it is quite obvious that the chromatin forms into linear masses which become increasingly distinct as the nucleus enlarges. Whether these chromatin masses are separate entities of definite number from their inception it is impossible to determine. As nuclear enlargement ceases, contraction of chromatin masses suggests that they are separate units from their start. With complete contraction are formed eight small but very distinct chromosomes somewhat irregularly arranged but as a group located much nearer the center of the hypo-

basidium than was the fusion nucleus (FIG. 1: 15, 16). These eight chromosomes separate equally, moving usually to a position near the wall of the hypobasidium and equidistant from the apex, but occasionally located diagonally in the hypobasidium (FIG. 1: 17, 18). Surrounding the nuclei is a relatively clear region which elongates as they separate but which does not exhibit any special structural details. At the end of the separation of the chromosomes the two daughter nuclei become definitely organized, and are only slightly larger than the nuclei occurring in the mycelium. Normally a second division follows immediately after the first, commonly simultaneously for the two nuclei; not infrequently one nucleus divides independently, while many cases may be observed in which no second division occurs. Consequently the mature hypobasidium may contain four, three, or only two nuclei, variously located in a now increasingly vacuolate protoplasm. In this second division four chromosomes are present in each nucleus.

The time of formation of the longitudinal septa in the hypobasidium is very variable, most frequently occurring after all nuclear divisions have ended. Almost invariably the direction of the septum is such that it divides the hypobasidium quite regularly from base to apex. However, inconspicuous variations do occur, particularly in the hypobasidia located at the base of the teeth or in the region between teeth, where hypobasidia may be divided unequally (FIG. 1: 29, 32, 33). At times the longitudinal septa entirely fail to form; at least, one may frequently find hypobasidia as in figure 1: 31, at a very advanced stage of development, yet showing no indication of any longitudinal septation.

In this fungus, epibasidial development seems not to start until all nuclear divisions are completed. The number of epibasidia formed appears invariably to equal the number of nuclei eventually found in the hypobasidium. The epibasidia developing between the teeth or at their bases are short blunt objects sometimes nearly parallel to each other, but more frequently growing out at wide angles (FIG. 1: 28–33). Often they are so short that the sterigmata appear to grow directly from the hypobasidium (FIG. 1: 37). The dimensions attained are from 2–3.5 μ in length, with a diameter of 1.5–2 μ. In the teeth, epibasidia develop more regularly, sometimes reaching a length of 10–12 μ. They often protrude

quite noticeably beyond the relatively scant "jelly" before contracting rather abruptly into the short, very slender sterigmata which form from their tips.

At the tip of each sterigma, a spore is formed in a manner exactly like that described for other members of the family—that is, there forms at the tip of the sterigmata a small spherical object which rapidly increases in size until the diameter of the mature spore is attained, and then elongates slightly. The same irregularity in time of spore formation occurs here as has been noticed elsewhere (*i.e.* Whelden, **4**), frequent instances being found where one of two to four epibasidia bears a mature spore before any other has started to form (FIG. 1: 30, 33).

Nuclear migration usually begins only when the spore has attained its mature size. Each nucleus migrates independently of its fellows, and moves with little change in shape except during the actual passage through the slender sterigma. Following migration of the nucleus there is rapid and almost complete withdrawal of all cytoplasm in the basidium, which however remains in an uncollapsed condition for some time, often until it is deeply immersed in a continually growing fruit-body.

The mature spores are conspicuously vacuolate uninucleate objects whose dimensions are 4–7 $\times$ 3.5–4.5 μ. Soon after falling from the sterigma each spore germinates by a short, coarse germtube at the apex of which is formed a slender tip bearing a secondary spore similar to the primary one. Into this secondary spore the nucleus migrates without dividing. Further development was not followed.

Sterile bodies.—There remain for consideration the various structures which may best be designated sterile bodies. These are more frequently encountered in the flattened surface of the fruit-body than in the teeth, and are all quite obviously of the same nature, namely, all are explainable as basidia which for some reason failed to develop as such. The structure most frequently found is very like the hypobasidium just before formation of the septa and development of the epibasidia; that is, they are subspherical objects located in the hymenium and having exactly the dimensions of the basidia (FIG. 1: 44–47, 49, 51). One striking contrast with a hypobasidium is observed, however, in that

these sterile structures contain very little cytoplasm which is usually present as a thin inconspicuous layer against the wall. Equally characteristic, if less conspicuous, is the nuclear nature of these structures—there is always a single small nucleus which may occupy any position within the cytoplasm. The explanation which suggests itself is that these are hyphal tips which received but one nucleus, and that they enlarge as do normal hypobasidia but do not develop the same abundance of cytoplasm. They finally become devoid of any cytoplasm, and remain as empty but distended bodies for a considerable time. At times one finds in these or in tips less swollen and provided with more evident cytoplasm a single small nucleus in a definite state of division, sometimes even showing four small closely massed chromosomes (FIG. 1: 50). These are not normal hyphal tips, however, since all are distinctly swollen and show definite thinness of cytoplasm which seems characteristic of these sterile objects. Quite infrequently one or more branches develop from the stalk-like portion of these sterile tips—these branches seem never to grow to any great extent, nor were they seen to contain any nuclei (FIG. 1: 48). Even less frequently one encounters tips in which more than one swelling occurs (FIG. 1: 43); no stages could be observed in the development of the latter. All these structures are found scattered among normal basidia, and seem in no way to be correlated with abnormal conditions, such as drought, but rather to be a natural development of the fungus.

TREMELLODENDRON CANDIDUM

The mycelium of the fruit-body of this fungus shows several different regions having rather distinct characteristics. Arising from the sandy soil in which the fungus was growing and forming the central portion of the much-branched fruit-body is a relatively dense zone of rather coarse hyphae containing a very scant peripherally located cytoplasm. Individual hyphae here are reasonably straight, branch but little, and have many septations, which form segments commonly containing one or two minute nuclei rather remote from one another (FIG. 2: 40); not infrequently segments are found entirely lacking nuclei. In the large number of slides made there were many which showed the cells in this central por-

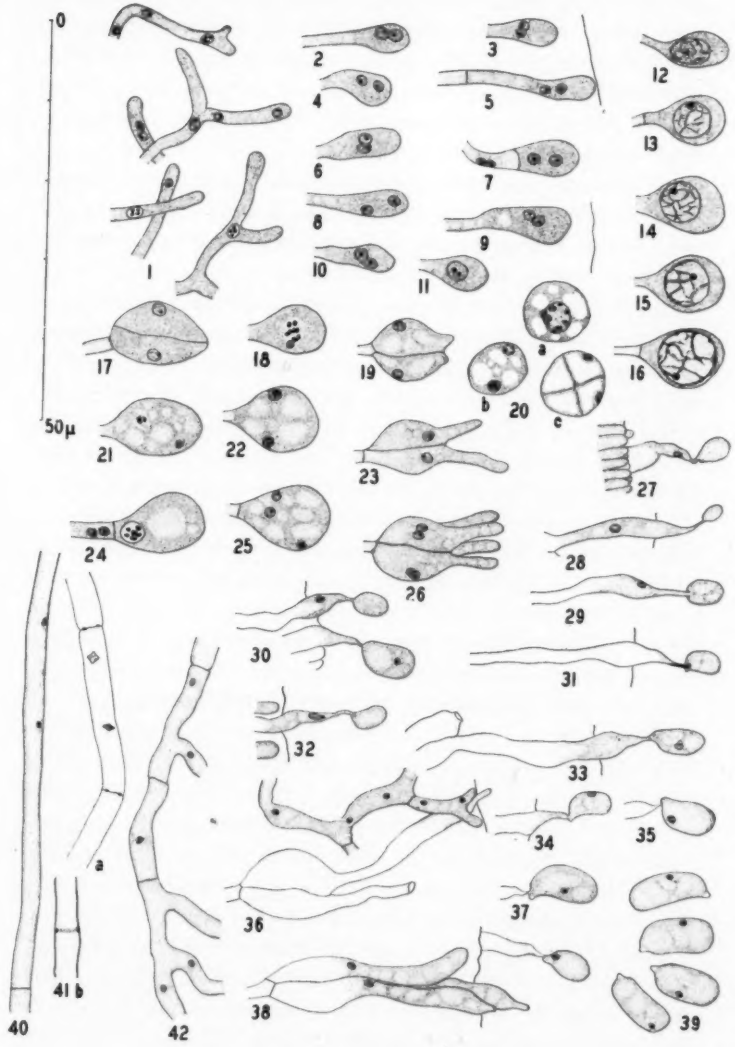

FIG. 2. *Tremellodendron candidum.*

tion containing one or two small dark-staining angular objects apparently of crystalline nature (FIG. 2: 41*a*). The similarity of their distribution to that of the nuclei suggests a possible connection between them. Casual examination would lead to their identification as nuclei; closer attention shows clearly their characteristic shape of thin square bodies with concave sides. The cross walls also are troublesome; many show a curious ring-like dark-staining portion appearing in section as two thick bars near the peripheral part of the wall (FIG. 2: 41*a*, *b*). The presence of these ring-like septa is more general than is that of the crystal-like objects.

External to this central zone of hyphae is a layer sharply set off from the first by its structure of loosely arranged, intricately tangled and irregularly much branched hyphae again composed of many segments of very diverse nuclear content (FIG. 2: 42). Often only one nucleus is present in a segment, more commonly two, and in rare cases three or more. In this layer also the hyphae are distinguished by the possession of a noticeably denser cytoplasm, while crystals and modified cross-walls are lacking.

Nearer the surface of the fruit-body this layer gradually blends into a third region less sharply set off from the second but still recognizably distinct. The hyphae comprising this surface layer are of smaller diameter, have conspicuously denser cytoplasmic content, possess noticeably larger nuclei not located peripherally, and in a growing condition are more obviously surrounded by "jelly" (FIG. 2: 1). The development of cross walls seems somewhat delayed in this superficial layer, so that there is a tendency for tips to be multinucleate. While rather small, many nuclei clearly showed the presence of four distinct minute chromosomes. The rounded tips of these hyphae do not form a dense surface layer but remain instead rather loosely arranged, a condition which continues throughout the period of basidial formation.

Basidia. Rather widely scattered beneath or at the surface of the maturing fruit-body, certain hyphal tips gradually become distinct through the presence of two closely associated nuclei, and also because of a very obvious enlargement. These enlarged tips seem invariably to be oriented horizontally, while within them the two nuclei occupy almost any relative position (FIG. 2: 2–10, inclusive). Frequently a basal septum cuts off the tip before nuclear

fusion occurs, the location of the septum being extremely variable; but usually not at the base of the enlarged portion.

Following fusion of the nuclei that of the nucleoli occurs, while both the basidium and the nucleus therein (FIG. 2: 11–15) continue to enlarge, until the latter has reached a diameter of 10 μ (rarely 12 μ). As in all cases in this family, there is the early appearance of the chromatin aggregates which become increasingly distinct as the nucleus enlarges. In the present instance these chromatin masses are very definitely located just beneath the nuclear surface. In thin sections, only zones of the fusion nucleus occur, so that the basidium often presents the appearance of two concentric rings including a minute zone of cytoplasm, while within the inner ring are small bits of deeply staining substance located in a very thin film of more faintly staining material. At times it is possible to focus down into a "bowl"-like section of the nucleus and identify these darker staining masses as sections of the chromatin masses. By far the greater part of the nucleus is completely unstained and seemingly unstainable, so far as the many different stains tried during the present study indicate. The impression one gets is that the nucleus is largely made up of a liquid which by increasing in volume distends the nuclear membrane and forces all nuclear substance outward, until practically the entire hypobasidium is occupied by the fusion nucleus (FIG. 2: 16). Throughout this development, the very small nucleolus remains a conspicuous object near the nuclear surface. The average final dimensions of the hypobasidium are $12 \times 8\,\mu$, while the diameter of the included nucleus is 10 μ.

Soon after maximum size is reached there occurs a rapid contraction of chromatin substance to form darker staining and distinct bodies still included by the nuclear membrane; the nucleolar substance begins to disappear; and the fusion nucleus shrinks rapidly from its maximum size (FIG. 2: 20*a*). As this contraction continues the nuclear membrane disappears, leaving eight small but perfectly distinct chromosomes free in the central part of the hypobasidium, which now contains a thin, vacuolate cytoplasm (FIG. 2: 18). Very rarely are the chromosomes located elsewhere than in the center of the hypobasidium; if elsewhere one generally finds them near the base, as in figure 2: 24 which shows them just

before the nuclear membrane disappears. Frequently a fairly evident pairing of the chromosomes may be observed.

Separation of chromosomes follows, the two groups migrating to a position near the wall of the hypobasidium and commonly in a transverse plane therein. Rather infrequently do they migrate in a longitudinal or diagonal direction, as shown in figure 2: 21. Having reached a position near the wall, the chromosome substance reorganizes to form the two daughter nuclei (FIG. 2: 17, 20*b*).

Ordinarily a second nuclear division follows immediately, the two nuclei usually dividing simultaneously, with four small chromosomes quite evident in each (FIG. 2: 22). These four chromosomes split equally so that eight pairs are frequently seen massed together in a nucleus, as in the lower nucleus of figure 2: 22. Quite commonly the two nuclei divide independently, as shown in figure 2: 21, 25, and 20*b*, while in other hypobasidia no second divisions occur. As a result of these variations, one may find hypobasidia which, at the end of the nuclear divisions, contain two, three, or usually four nuclei.

Septum formation seems not to be correlated with these nuclear events. As noted above, the time of formation of the basal septum, as well as its location, is extremely variable. Such is also the case in the longitudinal septa. As a rule the formation does not take place until nuclear divisions are completed; equally regular is their longitudinal orientation in the hypobasidium. When both have formed, the hypobasidium is divided into four almost equal parts. By this time the hypobasidium has become extremely vacuolate, with the minute nuclei located very close to the outer wall, often appearing somewhat flattened, as in figure 2: 20*c*.

Epibasidial formation begins in this fungus at the end of nuclear divisions and after the formation of the septa is completed. Nothing out of the ordinary is observable in their appearance as small apical protrusions (FIG. 2: 19) which gradually elongate until they reach the surface of the "jelly" of the fruit-body, at which time they may have a length of 24 μ, with a somewhat variable diameter of 1–3 μ (FIG. 2: 23, 26). An epibasidium may protrude slightly beyond the "jelly" before contracting rather gradually to form the sterigma, a slender object which may attain a length of 3.5 μ (FIG. 2: 27–33).

Spore formation offers little of interest, the process being almost identical with that found in all members of this group so far studied. The mature spores are borne at right angles to the surface of the fruit-body, and when fully mature are vacuolate bodies 8–10 × 3.5–4 μ (FIG. 2: 39).

Nuclear migration begins while the epibasidia are still forming. The nuclei become somewhat elongated at the beginning of their migration, and increasingly so as they near the apex of the epibasidia (FIG. 2: 30, 32). The location of the nucleolus may be apical or basal in the migrating nucleus. Necessarily in passing through the slender sterigma the nucleus becomes extremely attenuated (FIG. 2: 31). Once through, it immediately regains its original shape in which condition it moves to its final position in the distal half of the spore (FIG. 2: 34, 35, 37, 38). Its further history was not observed. Even before the beginning of nuclear movement, and becoming increasingly noticeable as migration continues, is the withdrawal of the cytoplasm from the basal portion of the hypobasidium (FIG. 2: 38). This withdrawal becomes very conspicuous when the nucleus is in the outer part of the epibasidium, at which time the hypobasidium has become almost devoid of cytoplasm, remaining as an uncollapsed structure surrounded by growing, branching hyphal tips (FIG. 2: 29, 33, 36). As the nucleus enters the spore, the cytoplasm in the epibasidium disappears leaving that object also lacking content, except in rare cases when a trace of cytoplasm may persist for a time in the apical portion (FIG. 2: 36).

It is worthy of notice that in *Tremellodendron* the basidia do not form a dense continuous hymenium at the surface, but rather that they occur as single bodies rather remotely scattered in the superficial layer, and constantly developing independently over a considerable period of time. This fungus seems less dependent than other Tremellaceae on the presence of abundant water for continuous spore formation.

DISCUSSION

In *Protodontia* the objects which seem worthy of specific note are the epibasidia and the sterile structures. In this genus the

dimensions of the epibasidia are obviously correlated with the amount of "jelly" present, and also with their location in the fruit-body. Epibasidia found in the teeth are of considerable length, while in the flat portion of the fruit-body they are poorly developed; in fact, many hypobasidia have almost no epibasidial structure, the sterigmata seeming to grow directly from the apex of the hypobasidium. In this flat region there is very little "jelly" above the hymenium, and so little need for any structure to penetrate such a substance.

The sterile structures found in *Protodontia* are readily interpreted as abortive basidia, being distinguished from true basidia by having only one small nucleus and an extremely thin cytoplasm. From their appearance one may decide that the fusion of two nuclei is not essential to cause enlargement but is necessary for further development of these bodies.

These observations on *Protodontia* substantially agree with those made by Kühner on *Protohydnum lividum* Bres. (1).

In *Tremellodendron* four different facts are worthy of notice. These are the hyphal structure of the fruit-body, the nature of the hymenium, the increase in size of the fusion nucleus, and the entire absence of sterile structures in the hymenium.

The first of these is the most noticeable, sharply distinguishing this fungus from all the other Tremellaceae so far studied by the writer. In the others, the hyphal structure of the entire fruit-body is remarkably uniform, while in *Tremellodendron* the fruit-body is composed of three distinct layers of hyphae. First there is a large central portion composed of closely aggregated hyphae extending lengthwise in the fruit-body, and almost devoid of protoplasmic content. In this region the septa are seemingly in process of digestion and disappearance, often being represented only by thickened peripheral rings. Surrounding this central region is a sharply distinct layer of intricately entangled, much-branched hyphae having a denser cytoplasm and which extend radially rather than longitudinally. Near the surface this layer gradually blends into a less distinct outer layer in which the basidia develop. This body structure of *Tremellodendron* resembles that of certain species of *Clavaria* far more than that of any other member of the Tremellaceae.

The nature of the hymenium in this genus is also very distinct. In all the other Tremellaceous fungi it has formed a dense rather uniform layer over a considerable portion of the exposed surface of the fruit-body. In *Tremellodendron* the hymenium is not continuous and lacks sterile bodies. In its formation individual hyphal tips, remotely and irregularly scattered, develop into basidia. One finds separate basidia developing to maturity and disappearing in succession over a considerable period of time, indicating that this fungus is less dependent on abundant moisture for spore formation than are any of the other members of the family.

In the hypobasidium, the tremendous increase in volume of the fusion nucleus over the two minute primary nuclei is most remarkable. This large fusion nucleus is easily studied and shows quite obviously the peripheral distribution of chromatin as nuclear enlargement progresses. This seems explicable as a consequence of the increasing amount of water which expands the nucleus to the greatest possible extent.

This study shows that the general cytological history of all members of the Tremellaceae is very similar. In spite of this general agreement, however, certain noteworthy points of difference stand out.

SUMMARY

Protodontia and *Tremellodendron* have the same cytological history as the other genera of the Tremellaceae studied by the writer. The following differences are noted, however. In *Protodontia* the epibasidia are definitely affected by the amount of "jelly" surrounding the hypobasidium and vary from very inconspicuous objects found in the flat surface of the fruit-body to long well-developed bodies found in the teeth. In this genus basidia-like sterile bodies occur, each containing only one nucleus and a very scant cytoplasm. In *Tremellodendron*, the fruit-body is composed of three layers: a central mass of densely packed hyphae growing longitudinally in the fruit-body; surrounding this, a layer of radially growing much-branched hyphae; and at the surface a layer of slender tangled hyphae in which are formed the basidia. The basidia do not occur as a continuous layer, but individually. The large fusion nucleus of a mature basidium has the chromatin

peripherally located. No abortive structures were observed in *Tremellodendron*.

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DESCRIPTION OF FIGURES

Fig. 1. *Protodontia uda* 1, multinucléate bit of mycelium from flat part of fruit-body; 2, 3, branched hyphal tips in surface of teeth; 4, 5, unbranched hyphal tips; 6, binucleate basidium initial; 7, 8, early stage of fusion nucleus, nucleoli distinct; 9, 10, enlarging fusion nuclei in as yet slightly swollen hypobasidia; 11–14, nearly mature hypobasidia, showing basal location of nucleus; 15, 16, chromosomes in center of hypobasidia; 17, separating chromosomes; 18, transverse section of hypobasidium, showing chromosomes at end of separation; 19, 24, binucleate hypobasidium; 20, formation of first longitudinal septum in hypobasidium; 21, 22, non-simultaneous second divisions before formation of longitudinal septa; 23, non-simultaneous second division after septum formation; 25, mature hypobasidium becoming vacuolate as nuclei migrate into epibasidia; 26, early spore formation in another binucleate basidium; 27, spores well advanced, cytoplasm leaving hypobasidium; 28, four-nucleate hypobasidium with well-developed epibasidia; 29, 30, hypobasidium showing unequal development of epibasidia; 31, 3-nucleate hypobasidium nearly mature but lacking septa; 32, 4-nucleate hypobasidia at beginning of nuclear migration; 33, irregular 4-nucleate basidium; 34, mature two-spored basidium; 35–37, 4-spored basidium showing non-uniform nuclear migration; 38, mature 3-spored basidium; 39, 40, mature spores; 41, 42, germination stages of spore; 43, sterile body showing two swellings; 44–49, various forms of uninucleate sterile bodies; 50, another with dividing nucleus; 51, basidia-like body having very short stalk.

Fig. 2. *Tremellodendron candidum* 1, hyphal tips in superficial layer of fruit-body; 2–10, binucleate basidial initials; 11, basidium with fusion nucleus, but unfused nucleoli; 12–15, hypobasidia with enlarging fusion nucleus; 16, mature fusion nucleus in hypobasidium; 17, binucleate hypobasidium with first longitudinal septum; 18, chromosomes free in hypo-

basidium; 19, binucleate hypobasidium with epibasidia forming; 20, cross sections of hypobasidium showing (*a*) formation of chromosomes, (*b*) binucleate condition, and (*c*) final 4-celled condition, two nuclei in plane of section; 21, non-simultaneous second nuclear division; 22, simultaneous second nuclear division; 23, mature hypobasidium with two well-developed epibasidia; 24, abnormal location of chromosomes at base of hypobasidium; 25, hypobasidium showing later stage of non-simultaneous division of nuclei; 26, mature hypobasidium with four well-developed epibasidia; 27–34, epibasidia showing stages in spore development, and in the nucleus during migration; 35, 37, nearly mature spore still attached to epibasidium; 36, empty hypobasidium with adjacent hyphal tip; 38, mature hypobasidium with three well-developed epibasidia; 39, mature spores; 40, hypha from central part of young fruit-body; 41, hyphae from central part of older fruit-body showing (*a*) included crystals, and (*b*) ring-like septum often present; 42, segmented hypha from second layer of fruit-body.

OBSERVATIONS ON SEXUAL RELATIONS IN HYPOMYCES IPOMOEAE

A. W. Dimock

(with 2 figures)

The occurrence of strains of different sexual reactions in the Ascomycetes was first discovered by Dodge (**12**) in the genus *Ascobolus*. Since this discovery, the following Ascomycete genera have been shown to possess such sexual strains: *Ophiobolus* (Kirby, **24**), *Gibberella* (Wineland, **28**, **29**), *Penicillium* (Derx, **10**), *Neurospora* (Shear and Dodge, **26**), *Ceratostomella* (Dade, **8**; Gregor, **20**; Buisman, **4**), *Pleurage* (Dowding, **16**; Ames, **1**; Zickler, **31** [*Bombardia*]), *Sclerotinia* (Drayton, **17**), *Hypomyces* (Zycla, **32**), and *Erysiphe* (Yarwood, **30**). Kirby's report (**24**) of heterothallism in the genus *Ophiobolus* has since been questioned by Davis (**9**). Likewise, Derx' report (**10**) of heterothallism in the genus *Penicillium* has been disputed by Blochwitz (**3**). Although Edgerton (**19**) early reported the occurrence of plus and minus strains in the genus *Glomerella*, both strains, though interfertile, were hermaphroditic and self-fertile as well. Hüttig (**23**) has recently published the results of studies of heredity in this genus. Only one of the strains used in his investigations was unisexual in reaction, however, the other being hermaphroditic and self-fertile.

An investigation of the sexual relations in *Hypomyces Ipomoeae* (Hals.) Wr., the imperfect stage of which is *Fusarium javanicum* Koord., was suggested to the writer by Professor H. N. Hansen. This fungus was known to produce perithecia in abundance and in a relatively short time on sterilized elderberry stems, but intensive studies of conditions required for perithecium formation had not been undertaken. An elderberry stem on which numerous perithecia of *H. Ipomoeae* had developed was kindly provided by Dr. W. C. Snyder of the California Agricultural Experiment Station staff. The fungus had originally been isolated by Dr. Snyder

from sweet-potato roots, and the sterilized elderberry stem planted with mycelium from a spore dilution plate. The dry stem was placed by the writer in a sterile test tube containing a few cubic centimeters of sterile water, and in a short time new perithecia developed in abundance.

DISCOVERY OF SEXUAL-REACTION GROUPS

A newly matured perithecium was removed from the stem with the aid of a sterile needle, washed in several changes of sterile water to remove adhering spores and finally placed in a drop of water on a sterile slide. The perithecium was then crushed with the point of a sterile needle, the operation being observed under the low power objective of the microscope. Mature ascospores were disgorged in large numbers when the rind of the perithecium was broken, and after adding a few drops of sterile water to reduce the spore concentration, the suspension was streaked on Petri plates of Czapek's agar by means of a sterile loop. The following day each mature spore had produced a germ tube 3 or 4 times the length of the spore. Isolated sporelings were then located by observations through the bottom of the Petri plates with the low power objective of the microscope and the locus of each marked with a dot of India ink. The plates were then righted and small bits of agar bearing the sporelings were transferred to slopes of malt extract agar in 1″ × 8″ culture tubes, the removal from the plates being observed with the aid of a dissecting microscope. In most cases the sporelings were examined with the 45 × objective of a compound microscope prior to transfer from the plates in order to check their purity. The presence of conidial contaminants or more than a single ascospore would of course vitiate the results.

The above technique was used in all the earlier studies and gave quite satisfactory results. The method, however, is very slow and laborious, and for this reason a modification of the method of Hansen and Smith (21) was employed in later work. Spores were streaked on agar and germinated as described above, but isolated sporelings were located directly with a dissecting microscope employing direct lighting. The spores were immediately removed with a sharp, sterile needle and either transferred directly to agar

slopes or first placed on a sterile spot on the agar plate, examined with the high-power objective of the microscope, and then transferred to the culture tubes. Ascosporelings were in every case examined with the compound microscope prior to transferring to culture tubes. An enormous saving of time was effected by this method with no sacrifice of accuracy.

Ninety-five single-ascospore cultures on malt-extract agar slopes were obtained from the initial perithecium, and in addition 5 sterilized elderberry stems were planted with a single ascosporeling, and 4 were planted with 2 single ascosporelings. Perithecia developed in abundance on three of the four stems on which 2 ascosporelings were planted, whereas none developed on the fourth. No perithecia developed on any of the five stems planted with a single ascosporeling. This preliminary test strongly indicated the presence of self-sterile strains of opposite sexual reactions.

In the meantime the 95 single-ascospore cultures on malt slopes had remained essentially alike, and none had developed perithecia. The term "essentially alike" is used here advisedly, for no two cultures are ever identical, slight variations occurring due to small differences in the amount of medium, differences in the cleanliness of the glass tubes, differences in the amount of agar transferred with the spore, etc. Such variations are slight and their range quickly learned, so that they lead to no confusion. Eighteen of these cultures were taken at random and mated in all possible combinations on sterilized elderberry stems. The cultures fell into two intra-sterile, inter-fertile groups, 13 cultures comprising one group, 5 the other. The reactions were in every case quite clear-cut. *The occurrence of self-sterile strains of opposite sexual reaction in Hypomyces Ipomoeae is thus definitely proved.*

A phenomenon was noted in nearly all the above sterile cultures which, until understood, caused some anxiety. This was the appearance of small, reddish, spherical bodies which closely resembled young perithecia. Microscopic examination of these bodies, however, showed them to be quite sterile. The control cultures of the single-ascospore strains were carefully re-examined and similar sterile perithecium-like bodies were found in nearly all cultures, whether of one sexual reaction or the other. This ob-

servation has been borne out in all subsequent work with the normal strains.

Similar sterile bodies were noted by Dodge (**13**) in *Neurospora sitophila* strains of both sexual reactions. He termed them "sclerotia" or "bulbils" and considered them to function as true sclerotia. Colson (**5**), by cytological investigation, has shown that these "sclerotia" are in reality perithecial fundaments, being composed of sterile hyphae in which the "archicarps" are encased. Sterile-bodies are also reported by Ames (**1, 2**) and Zickler (**31** [*Bombardia*]) in strains of both sexual reactions in the genus *Pleurage*. Ames proved unquestionably that these bodies encase the female sex organs. Gregor (**20**) has noted such sterile bodies in strains of both sexual reactions in *Ceratostomella pluriannulatum,* and regards them as female sex organs. Hüttig (**23**) reports the occurrence of "sklerotia" in his "male" strain of *Glomerella Lycopersici.* He considers these sterile bodies as male sex organs—"Die 'Sklerotia' enthalten nur Hüllhyphen und Antheridien." In view of the researches of Colson (**5**) and Ames (**1, 2**) noted above, and of Drayton (**17, 18**) on *Sclerotinia Gladioli,* in which the sterile bodies in *Neurospora, Pleurage* and *Sclerotinia* are proved to be female in nature, Hüttig's interpretation is open to question.

Cytologic investigations of the sterile bodies in *Hypomyces Ipomoeae* were not undertaken, but by analogy to the above cases they are assumed to be perithecial fundaments and to be female in nature. This hypothesis is supported by the observation that in all fertile pairings the fundaments proceed to develop into fertile perithecia. It is thus proposed that the strains of opposite sexual reactions in *Hypomyces Ipomoeae* are hermaphroditic and self-sterile, but inter-fertile. The existence of such strains in *Pleurage anserina, Sclerotinia Gladioli, Neurospora tetrasperma* and *N. sitophila* has been proved by Ames (**1, 2**), Drayton (**17, 18**) and Dodge (**14**). These species possess not only female bodies but also male sex organs which produce spermatia ("microconidia" in *Neurospora,* Dodge, **14**), thus permitting definite proof of hermaphroditism, self-sterility and inter-fertility. Examination has thus far disclosed no male sex organs in either strain of *Hypomyces Ipomoeae,* but evidence will be presented

later which suggests that the conidia may function in the capacity of spermatia, as has been proposed by Dodge (**14**) for the monilioid conidia of *Neurospora*.

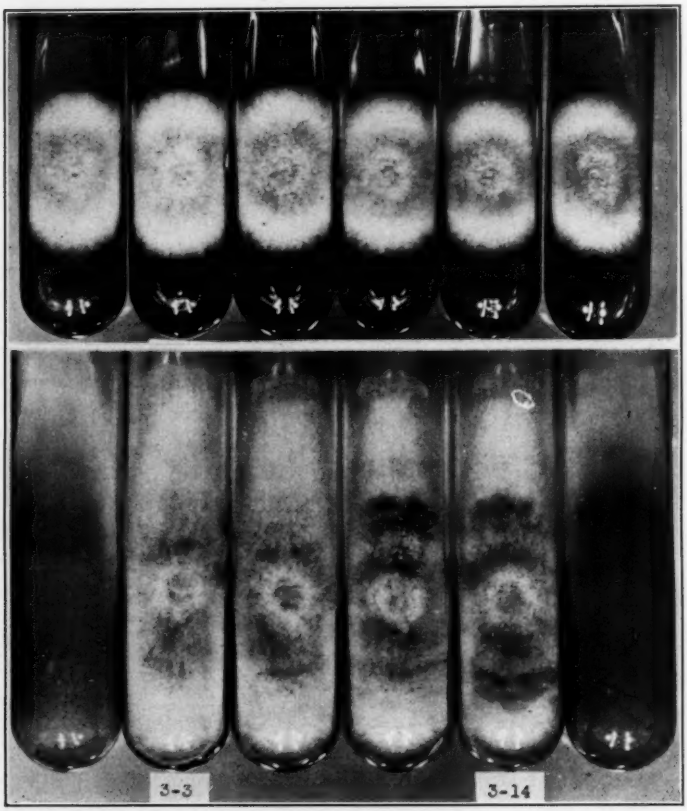

FIG. 1. Single-conidium cultures of the normal strains of *Hypomyces Ipomoeae* on potato-dextrose agar. In each photo the 3 cultures on the left bear the sexual-reaction factor *A*, the 3 on the right the factor *a*. Upper, cultures 4 days old; lower, cultures 9 days old.

Two self-sterile, inter-fertile strains, 3–3 and 3–14 (FIG. 1), were selected from the above 18 single-ascospore mycelia to serve as tester strains in all subsequent studies. Following the precedent

of Zickler (**31**) and Dodge (**15**), the two strains have been assumed to bear sexual-reaction factors designated as *A* and *a*, respectively. These strains were mated on numerous media and it was soon apparent that perithecia, which developed in all matings, were produced most rapidly on ordinary potato-dextrose agar. This medium has hence been used in nearly all matings. Single-ascospore mycelia from seven perithecia developing in various 3–3 × 3–14 crosses have been tested for sexual reaction. The results are indicated in Table 1.

TABLE 1

DISTRIBUTION OF SEXUAL-REACTION FACTORS IN SINGLE-ASCOSPORE CULTURES OF HYPOMYCES IPOMOEAE

Perithecium	Sexual-reaction factor		Ratio *A*/*a*
	A	*a*	
X	10	6	1.67/1
E1	12	8	1.50/1
E2	12	16	0.75/1
E3	11	26	0.42/1
E4	12	8	1.5/1
E6	28	23	1.22/1
E7	10	8	1.25/1
Total	95	95	1/1
Initial perithecium	13	5	2.60/1
Total	108	100	1.08/1

The data show that of the 190 single-ascospore mycelia, 95 possessed sexual-reaction factor *A*, 95 the factor *a*—an exact 1:1 ratio. If data on the initial perithecium are included the values become 108 and 100, respectively, and the ratio 1.08:1. A 1:1 ratio would be expected on the assumption that sexual reaction is conditioned by a single gene pair. It is therefore concluded that sexual reaction in *Hypomyces Ipomoeae* is conditioned by a single pair of factors which segregate at meiosis according to Mendelian expectancy.

The tests of sexual reaction were at first made by back-crossing each single-ascospore culture with both tester strains. This method obviously involved considerable transferring and was so time-consuming that a more simple, but equally reliable, test

method was sought. The following procedure was found in trials to be quite satisfactory, and was used to determine the sexual reaction of all normal mycelia in subsequent tests. One cubic centimeter of a concentrated suspension of microconidia of one tester strain or the other in sterile distilled water was added to each single-ascospore culture to be tested. Within 5 days perithecia could be seen with the naked eye to be developing on all parts of the culture which had been wet with the spore suspension (FIG. 2). The age of the single-ascospore cultures so tested varied from 10 days to more than three months, and in all cases the same definite results were obtained. The reaction is so pronounced that the development of perithecia may be taken as proof that the sexual reaction of the single-ascospore strain is opposite that of the tester strain. Failure to develop perithecia, on the other hand, may be taken as definite evidence that the sexual reaction of the ascospore strain is the same as that of the tester.

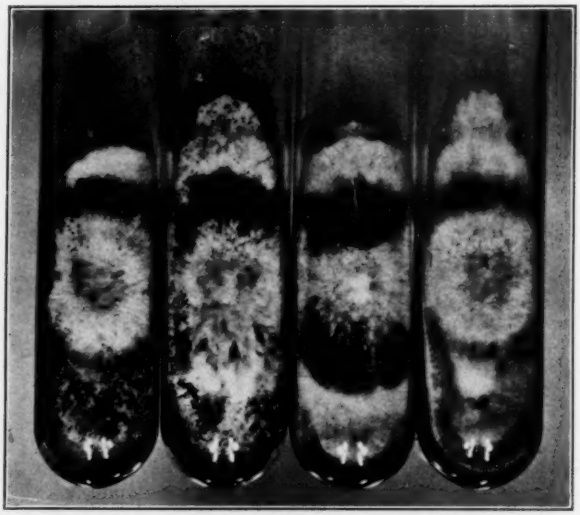

FIG. 2. Old cultures of normal strains which have been "spermatized" with a suspension of microconidia of the tester-strain (3–14) bearing sexual-reaction factor *a*. The two cultures on the left must bear sexual-reaction factor *A*, the two on the right the factor *a*.

It has been observed that in all cases in which the above method has been used, perithecia developed only on those portions of the colony which had actually been wetted by the microconidial suspension. When single drops of spore suspension were added, perithecia developed only within the limits of the drop. Furthermore, since the perithecia become quite evident in 5 days, it is obvious that their development is initiated very soon after the addition of the spore suspension. In single-spore cultures, perithecial fundaments develop when the cultures are 8 or 9 days old, and in normal matings fertile perithecia become evident when the cultures are 10 or 15 days old. All single-ascospore cultures to which spore suspension has been added have been old enough to have developed perithecial fundaments in abundance. This, coupled with the fact that perithecial development immediately ensues only on those portions of the cultures actually wetted by the spore suspension, leads to the conclusion that conidia (or perhaps any vegetative cells) may function in spermatizing the perithecial fundaments, which have been assumed to bear the female sex organs. The ability of both microconidia and macroconidia of *Neurospora tetrasperma* and *N. sitophila* to function in spermatization has been previously demonstrated by Dodge (**14**) with similar experimental methods.

Throughout the course of this investigation watch has been kept for secondary sexual characters in the normal strains, *i.e.*, morphologic or physiologic expressions definitely linked with the strains of one sexual reaction or the other. Five consecutive culture-series consisting of 25 single conidia each have been made of both tester strains, malt-extract agar being used as the substrate. Scores of mass transfer and single conidium cultures of the two strains on various other substrates have also been observed. It was at times believed that definite differences of one sort or another could be discerned, but none of these proved constant. An example of such a difference is illustrated by the cultures pictured in figure 1. All three of the 9-day-old cultures of 3–14 (*a*) apparently have a pigmentation of the basal mycelium not possessed by any of the three cultures of 3–3 (*A*). All such dissimilarities have proved evanescent or so poorly marked as to

be unreliable. The "normal" strains of opposite sexual reactions may be regarded as morphologically indistinguishable.

Mention must be made here of certain variant mycelia. A single ascospore, E3/1, developed a very unusual type of mycelium which bore no resemblance to the normal, being extremely slow-growing, developing very few conidia, and possessing marked reddish-purple pigmentation. Again, a number of single ascospores have developed a distinct "purplish" type of growth which resembles the normal in growth-rate and fluffiness of mycelium, but which develops purple pigment and produces conidia much less abundantly than the normal. Fourteen of the 208 single-ascospore cultures have been of this type. Since we are concerned here only with sexual phenomena, suffice it to say that all the variants were fertile, and those of the "purple" type showed an almost exact 1 : 1 distribution of the sexual-reaction factors. A detailed discussion of these and other ascospore variants will be included in a later paper. All single-ascospore cultures save the 15 noted above have fallen well within the normal limits.

DISCUSSION ON SEXUAL PHENOMENA IN HYPOMYCES IPOMOEAE

The experiments reviewed in the preceding pages have proved beyond question the existence of monoploid, self-sterile, inter-fertile strains in *Hypomyces Ipomoeae*. Observations on the presence of perithecial fundaments in monosporous mycelia of either reaction, and observations on the apparent spermatizing action of conidia are believed good evidence that both strains are hermaphroditic and are completely inter-fertile.

Hermaphroditic mycelia in this species are seen to arise from single ascospores and from single unicellular microconidia. Although cytologic studies of ascospore formation in this species have not been undertaken, we may assume that, as is conceded to be the case in most Ascomycetes possessing 8-spored asci, each ascospore initially contains a single haploid nucleus. Cytologic studies of Dickinson (**11**) on certain species of *Fusarium*, and preliminary studies made by the writer on *Hypomyces Ipomoeae*, indicate that most unicellular microconidia of *Fusarium* species contain but one nucleus at the time of abstriction. These observa-

tions lead to the conclusion that in this and other similar forms (*Pleurage, Sclerotina,* 8-spored *Neurospora* spp.) *each monoploid nucleus possesses the potentialities of both sexes.* This theory has been supported by Correns (**6**, **7**), Wettstein (**27**), Hartmann (**22**), Ames (**2**), and others.

Sex chromosomes or sex genes as such are not, then, segregated in the maturation divisions. It must be assumed, rather, that an allelomorphic pair, *Aa*, determining fertility and sterility is concerned. Matings of two strains bearing the factor *A*, or of two strains bearing the factor *a*, would be sterile, while matings of two strains, one bearing *A* and the other *a* would be fertile. The theory of sterility factors or compatibility factors has likewise been advanced to explain the condition in *Neurospora* (Lindegren, **25**) and in *Pleurage* (Ames, **2**; Zickler, **31**).

The mode of operation of such reaction-factors is suggested by the work of Ames (**2**) on *Pleurage anserina.* He found that when a spermatium from a compatible strain was applied to a receptive hypha of an ascogonium, it soon lost its contents, and the ascogonium developed a fertile perithecium. Incompatible spermatia, or spermatia from the same mycelium, when similarly applied, did not lose their contents, nor did the ascogonia develop perithecia. In the present case it may be that hyphal fusion or spermatization by conidia is prevented between strains bearing like sexual-reaction factors, or that, plasmogamy being effected, karyogamy is inhibited. The work of Ames favors the former proposal.

SUMMARY

Intensive studies of 208 single-ascospore mycelia of *Hypomyces Ipomoeae* have shown each to be self-sterile and to fall into one or the other of two reaction groups. Members of each reaction-group are sterile when mated *inter se,* and react with only one of the two tester-strains bearing opposite sexual-reaction factors. All matings of members of one group with members of the other group have proved fertile.

All single-spore mycelia produce sterile bodies which are with reason assumed to bear the female sex organs. Nearly all such bodies in compatible matings develop into fertile perithecia.

Microconidia of members of either reaction-group appear to be capable of "spermatizing" the female sex organs of members of the other reaction-group.

It is proposed that each single-ascospore mycelium is hermaphroditic, but self-sterile. Each monoploid nucleus must, then, possess the potentialities of both sexes. Hence, sexual-reaction factors, rather than sex factors or sex chromosomes as such, are segregated at meiosis. The data strongly suggest that a single allelomorphic pair is concerned.

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SEPTOTINIA, A NEW GENUS OF THE CIBORIOIDEAE[1]

H. H. Whetzel

(with 18 figures)

The subfamily Ciborioideae of the Helotiaceae embraces a well-marked group of discomycetous fungi the species of which are commonly referred to the genera *Ciboria* and *Sclerotinia*. Nannfeldt (**1932**: 307) includes in this group the two above-named genera and *Monilinia*, established by Honey (**1928**) for species having a monilioid conidial stage, which he thus segregates from *Sclerotinia*.

Among the many species commonly referred to *Ciboria* or *Sclerotinia* are several other groups having well-marked generic characters which warrant their segregation under new generic names, for example those species having a conidial stage of the *Botrytis cinerea* type. The genus to be described in this paper is characterized by a type of conidial fructification heretofore entirely unsuspected as belonging to an apothecial fungus. The apothecial stage, here for the first time reported, is typical of the Ciborioideae.[2] But one species of this genus is at present known to the author.

[1] This is the fourth paper in the series of studies on the North American species of *Sclerotinia* and related genera (Mycologia **18**: 224; **21**: 5; **28**: Nov.–Dec.).

Acknowledgments. The writer is under special obligations to Dr. John Dearness for his generous permission to publish his manuscript notes on the conidial stage of this species. He is indebted to Miss Cynthia Westcott for her assistance in the preliminary studies on this fungus, to Miss Ruby Rice for the drawings and other help in completing the manuscript, and to Mr. R. W. Fisher for taking the photographs. Much of the preliminary work embodied in this paper was done on a grant from the Heckscher Foundation for the Advancement of Research at Cornell University. Its completion has been made possible by a grant from the Penrose Fund of the American Philosophical Society.

[2] The writer presented a preliminary report on this fungus at the first annual meeting of the Mycological Society of America at Atlantic City in December 1930. Neither the paper nor an abstract of it was published.

While on a visit to Swarthmore College on May 1, 1927, the writer collected a number of minute apothecia (FIG. 1) of the Ciborioideae type, growing from slender, flat, black sclerotia in the soil and leafmold under rapidly expanding plants of *Podophyllum peltatum*. Ascosporic sowings on potato dextrose agar gave cultures which in about two weeks produced a number of more or less circular, thin, flat, black sclerotia on the surface of the media. On a second visit to the same spot, about five weeks later (June 4), it was discovered that the leaves in this patch of *Podophyllum* were generally and severely infected with a fungus producing very large, circular, hydrotic lesions (FIG. 8).

It was at once suspected that these lesions were the result of ascosporic inoculation from the apothecia discovered early in May.

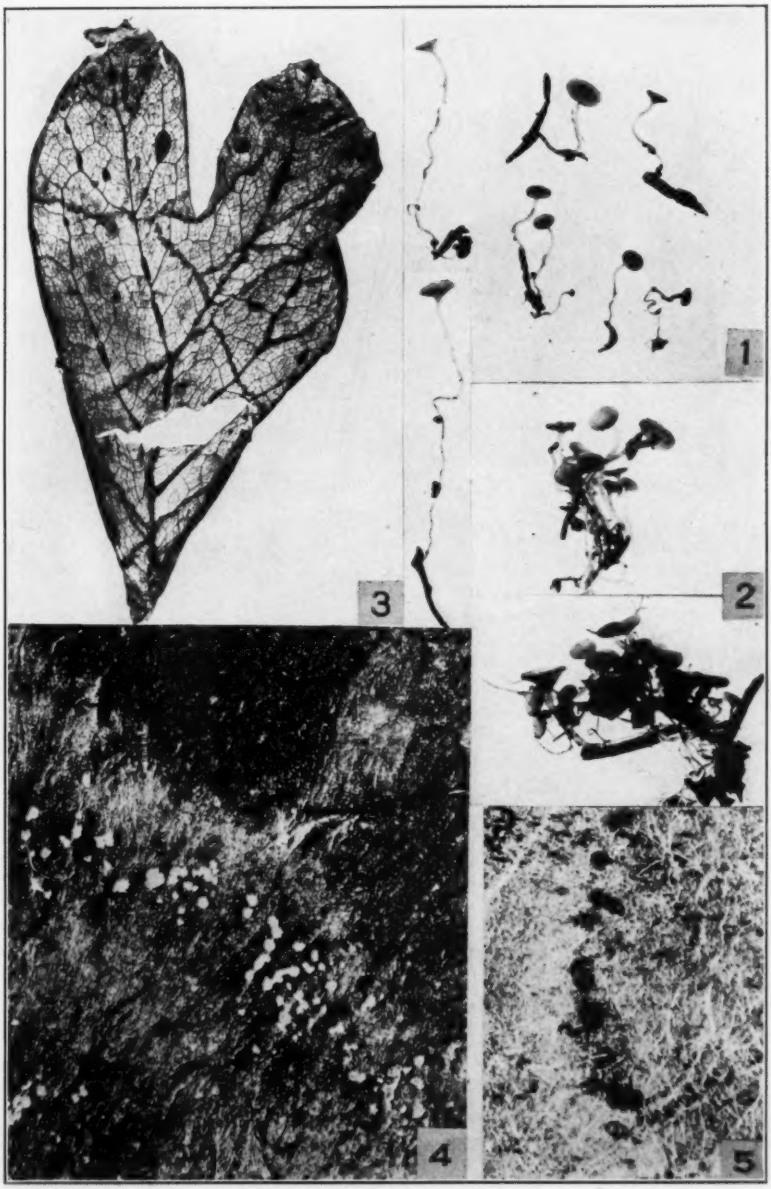
Examination with the hand lens showed minute white sporodochia of a conidial stage scattered over both sides of the lesions (FIG. 4, 7). Tissue plantings from the advancing margins of active lesions, and conidial dilution-cultures, on potato dextrose agar, gave cultures identical in all respects with the ascosporic sowings on the same medium which had been made from the collection of apothecia of May 1. Diseased leaves placed in a moist chamber on wet filter paper rapidly rotted with abundant development of sclerotia, especially along the veins (FIG. 3). These were slender, flat, angular, and pointed like those from which the apothecia developed, occasionally circular, like those produced in culture. Disinfested with calcium hypochlorite and planted on potato dextrose agar, these sclerotia promptly gave cultures identical with the cultures from ascosporic sowings, tissue plantings and conidial dilution-cultures. Sclerotia produced from mass ascosporic sowings on potato dextrose agar slants and held on moist sand at 15° C. produced apothecia in nine months. When held at room temperature apothecia developed in four months. Repeated isolations from ascospores, tissue plantings, conidia and sclerotia from specimens collected in this and other localities, since the spring of 1927, have established beyond question the genetic relationship of the apothecial and conidial stages.

IDENTITY

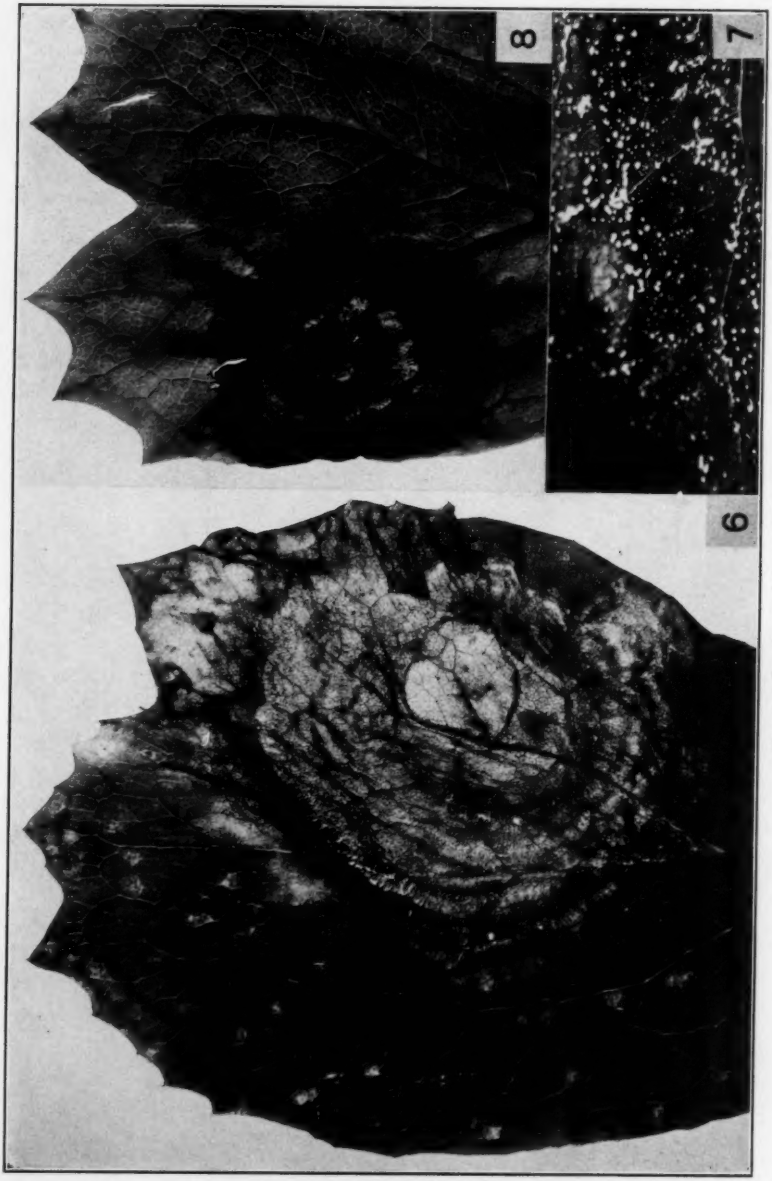
The identity of the fungus was first disclosed when some specimens of the conidial stage freshly collected at Swarthmore, Pa., May 17, 1929, were taken to the herbarium of the United States Department of Agriculture at Washington, D. C., where attention was called by Dr. Vera K. Charles and Dr. W. W. Diehl to the collection of *Gloeosporium podophyllinum* Ellis & Ever. (N. Am. Fungi *2442*). A careful microscopic examination showed our fungus to be the same as that in this specimen.

The first collection of this fungus appears to have been that made by the Rev. C. H. Demetrio (his number *157*) at Concordia, Mo., in May, 1888, to which specimen alone reference is made by Ellis (**1888**: 103) in his original description of the species. This specimen of the conidial stage is now in the Mycological Herbarium of The New York Botanical Garden. Saccardo (**1892**: 497) transferred the species to the genus *Septogloeum* because of the septate character of the conidia. The fungus has been distributed in two exsiccati, *viz.* Rabenhorst-Pazschke, Fungi Europaei *4286*, collected by Demetrio at Emma, Mo., June, 1888; and in Ellis and Everhart, North American Fungi *2442*, collected by Demetrio at Concordia, Mo., 1889.

Some work on the conidial stage of this fungus by the veteran Canadian mycologist, John Dearness, deserves consideration. In some lists of fungi published by Dearness (**1926**) he refers this fungus, on p. 66, to *Gloeosporium podophyllinum* Ellis & Ev. On page 71 of the same paper he refers it to *Septogloeum podophyllinum* (Ellis & Ever.) Sacc., with the interesting remark, "A *Septoriopsis*." Correspondence with Dearness discloses that this reference of the fungus in the same paper to two different genera was an oversight due to his not having seen the proof of this paper before it went to press. His suggestion that it is "A *Septoriopsis*" foreshadowed an unpublished paper he had in manuscript as the result of his studies on specimens sent him by Burnham from Fort Ann, N. Y., in June, 1920. The paper by Stevens and Dalbey (**1919**) suggested to Dearness that this fungus fell in the genus *Septoriopsis* there established. Petrak's (**1924**) emended description of the genus *Septogloeum* excluding forms like this on



FIGS. 1–5. *Septotinia podophyllina.*



FIGS. 6-8. *Septoinia podophyllina.*

Podophyllum, having raised in Dearness' mind certain questions which he wished to examine in the light of a personal acquaintance with the fungus in the field, he decided to delay publication. The manuscript still remained unpublished at the time (July 29, 1932) I first wrote him inquiring as to the occurrence of the fungus in Canada. As a result of our correspondence Mr. Dearness sent me a copy of this manuscript which, with his permission, is presented below:

"**Septoriopsis podophyllina** (Ellis & Ev.) comb. nov.

"Syn. *Gloeosporium podophyllinum* Ellis & Ev. Jour. Myc. **4**: 103. 1888.

"*Septogloeum podophyllinum* (Ellis & Ev.) Sacc. Syll. Fung. **10**: 497. 1892.

"*Exsic.* Ellis & Ev. N. Am. Fungi *2442;* Rabenh.-Paz. *4286.*

"'On light brown (1 cm.) spots with a darker greenish border. Acervuli amphigenous, white erumpent. Spores variable in size and shape, ovate, 12–15 × 5–7 microns or oblong and cylindrical, straight or curved, hyaline, 1–3 septate, 20–35 × 4–7 microns'—l. c.

"Mr. Burnham's collection affords all the features of the original description and warrants the following additions and modifications. Spots 1 cm., subcircular, irregularly extending to 5 cm., bordered and often more or less concentrically zoned with dark green, translucent and plainly showing the acervuli when observed from either side but erumpent mostly in the upper surface. Tubercles or 'dochia' of short-celled (or up to 60 microns) plectenchyma, either subcuticular or superficial and bearing conidia in all stages of development, continuous and up to 4- or more-septate, attaining a length of 54 microns or more and width of 7 microns and tending to break up. Some of the carpa might very well pass for *Phleospora.*

"On *Podophyllum peltatum* L. West Ft. Ann, N. Y.; June, 1920. S. H. Burnham *366* (D. *1163*)."[3]

Dearness' suggestion (above) that this conidial stage may fall in the form-genus *Phleospora* (Wallroth **1833**) is not tenable since

[3] This collection by Burnham is now deposited in the Plant Path. Herb. Cornell University under the number *21043.*

FIGS. 6–8. *Septotinia podophyllina.*

the conidiophores of fungi in *Phleospora* are said to be simple. In our fungus they are commonly branched.

This fungus has certain characters which might seem to warrant its reference to the genus *Septoriopsis* of Stevens and Dalbey, which they place in the Tuberculariaceae-Scolecosporae of the Hyphomycetes (Moniliales-Scolecosporae, according to Clements and Shear [**1931**: 399]). It should be pointed out that it cannot be referred to the genus *Septoriopsis* established by Fragosa and Paul (Fragosa **1915**) since this is a genus of the Sphaeriales. Moreover, since the establishment of the genus *Septoriopsis* by Fragosa and Paul antedates that of Stevens and Dalbey, the name is untenable for the genus concept of the latter authors. This is pointed out by Petrak (**1925**: 69), who proposes the name *Cercoseptoria* for Stevens and Dalbey's genus. The conidiophores in that genus are simple and unbranched, and the conidia narrow and multi-septate. The much-branched character of the conidiophores and the broad, apically attenuated shape of spores of *S. podophyllinum* seem to clearly exclude its conidial stage from this genus; nor can it be referred to *Septogloeum* as emended by Petrak (**1924**). Since the perfect stage of this fungus has now been discovered, and since it is almost certain that the conidial forms referred by Stevens and Dalbey to their genus *Septoriopsis* are not congeneric with that of our species, there appears to be no valid grounds in the present case for erecting a new form-genus for the conidial stage of our fungus.

TECHNICAL DESCRIPTION

Septotinia [4] gen. nov.

Conidia hyaline, elongate, septate, borne on branched, hyaline conidiophores massed to form a typical sporodochium.

Sclerotia angular, elongate or circular, thin, black, formed in the invaded tissues of the affected plant parts, usually after they have fallen to the ground.

[4] In adopting the name *Septotinia* for the fungus on *Podophyllum*, the writer does not intend to convey the idea of generic relationship with the form-genus *Septogloeum*, but merely to suggest the septate character of the conidia. He is aware of the hybrid etymology of this word, but coins it thus for its euphony and implications.

Spermatia[5] (microconidia) ovate, very minute, produced on short, Indian club-shaped spermatiophores, clustered to form minute spermadochia on the decaying tissues; accompanying formation of sclerotia.

Apothecia shallow, cup-shaped, stipitate, arising in the spring from sclerotia in the soil or leafmold. Asci slender, cylindrical; ascospores hyaline, ovoid; paraphyses simple or branched, tips swollen.

Septotinia podophyllina (Ellis & Ev.) comb. nov.

Syn. *Glocosporium podophyllinum* Ellis & Ev. Jour. Myc. **4**: 103. 1888.

Septogloeum podophyllinum Sacc. Syll. Fung. **10**: 497. 1892.

Conidia hyaline, elongate, 0–4-septate, straight or curved, often breaking apart at the septa when mature, truncate at the base, attenuated toward the apex, very variable in length, about 6 μ in width (FIG. 13),[6] borne on branched, hyaline, septate conidiophores

No.	No. measd.	No. cells	Limits	Average	Mode
S1219	7	1	12.5–22.5 × 5.0–7.5	17.5 × 5.7	17.5 × 5.0
	55	2	17.5–40.0 × 5.0–7.5	24.5 × 5.9	25.0 × 6.3
	33	3	20.0–37.5 × 5.0–7.5	30.5 × 6.1	32.5 × 6.3
	5	4	35.0–45.0 × 5.0–6.3	41.0 × 6.0	42.5 × 6.3

[5] Since the so-called microconidia of the Discomycetes as well as those of the Pyrenomycetes and lichen fungi doubtless function in fertilization (Drayton **1932, 1934**; Ames **1934**; Dodge **1932, 1936**; and Bachmann **1912, 1913**), the writer proposes to revert to the original appellation for these cells, *viz., spermatia* (Tulasne **1852**: 157; **1861**: 181). Furthermore when, as in this case, the spermatial fruit-body consists of a naked cushion or cluster of spermatiophores, it will be designated as a *spermadochium* to distinguish it from the thecal type to which Tulasne (**1852**: 157) originally applied the term spermagonium, the form of spermatial fruit-body usually characteristic of the lichen fungi and the Pyrenomycetes. This terminology is to be preferred to "microconidia" and its derivatives in spite of the fact, as shown by Brierly (**1918**) and Dodge (**1932**), that the spermatia in some forms and under certain conditions may germinate and function as true conidia. Ames' (**1934**) use of "antheridium" to designate the spermatiophores is of doubtful validity since the spermatia are apparently not endogenously produced.

[6] The following table shows the approximate proportion of 1-, 2-, 3-, and 4-celled conidia with their respective measurements in a random sampling of 100 conidia from the type collection, No. *25277*.

(FIG. 12) which are densely clustered to form minute, white, mucilaginous sporodochia (FIG. 11), which become horny and often amber-colored when dry. Sporodochia gregarious or scattered over either or both sides of leaf lesions (FIG. 4, 7); usually most numerous on the upper surface, arising beneath the cuticle from the large hyphae of the rhizomorphic, fibrillose, fan-like radiations of the subcuticular mycelium.

Sclerotia formed in invaded tissues of the dead leaves (FIG. 3) and stalks on the ground, most commonly along the veins; including remnants of the tissue embedded in the white medulla (FIG. 10); angular, elongate, or circular, thin, black, 3–5 mm. long by 1 mm. broad.

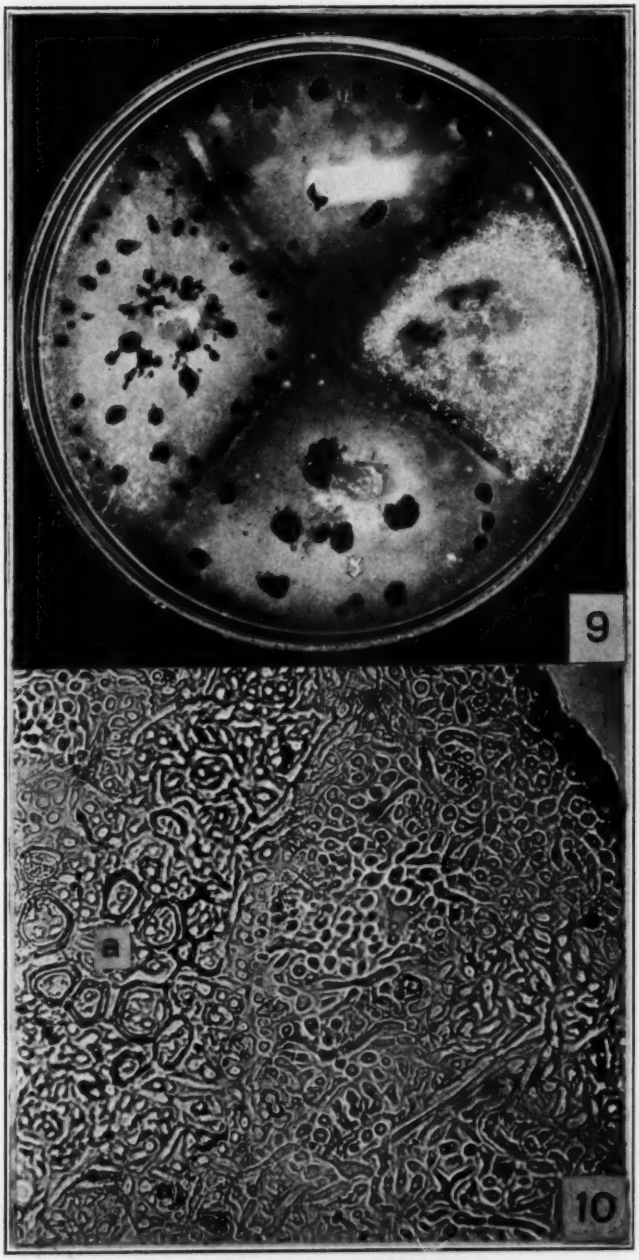
Spermatia accompanying the formation of sclerotia; minute, ovate, 2.4–3.6 × 1.5–2.1 μ, average 2.7 × 2.1 μ, mode 3 × 2.1 μ,[7] with a short stalk or collar, hyaline; produced successively from the tips of densely clustered Indian club-shaped spermatiophores, which form minute (almost microscopic), subcuticular, amber-colored spermadochia on the decaying leaf tissues (FIG. 5). Spermatia often remaining in long chains enclosed in a hyaline gelatinous sheath (FIG. 18).

Apothecia shallow, cup-shaped, stipitate, arising from sclerotia on or in the soil or leafmold (FIG. 1, 2); cups 1–4 mm. broad, of a pale fawn color (R); stipe tapering from the cup downward, smooth, concolorous with the apothecium. Asci (FIG. 16) 8-spored, slender, cylindrical, apical plug staining blue with iodine. Measurements of 25 asci of the type specimen, No. *25277*, gave limits of 116–148 × 7.5–10 μ, average 127 × 8.8 μ, mode 130 × 8.4 μ. Ascospores ovoid, hyaline, 1-celled (FIG. 16); measurements of 50 spores gave limits of 10–16 × 5–6 μ, average 13 × 5.6 μ, mode 12.5 × 5.6 μ.[8] Paraphyses slender, tips irregularly swollen, septate, usually simple, sometimes branched (FIG. 16).

Growing readily on potato dextrose agar where some strains are usually chromogenic, staining the medium cadmium-yellow to raw sienna (R), forming pruinose, floccose or tufted aerial my-

[7] Measurements of 100 spermatia from potato dextrose culture of single conidial isolate of the type specimen, No. *25277*.

[8] Fifty measurements from each of 5 other collections gave ascus lengths somewhat greater, 120–160 μ, but of the same width as the type. Ascus measurements often vary greatly in different collections of the same species in the Ciborioideae. One hundred measurements from each of these same collections gave ascospore measurements almost identical with those found in the type specimen.



FIGS. 9–10. *Septotinia podophyllina.*

celium, circular, thin, flat, black sclerotia, and spermatia. Optimum temperature for growth and scerotial production 18–24° C. The conidial stage is pathogenic to leaves of *Podophyllum peltatum* in eastern North America. Known from New York, New Jersey, Delaware, Pennsylvania, Maryland, West Virginia and Missouri.

HERBARIUM MATERIAL. Type specimen No. *25277* is deposited in the Plant Path. Herb. Cornell University (sclerotial, apothecial and conidial stages). Duplicate material from this same collection has been deposited in the following herbaria: Harvard University; New York Botanical Garden; Royal Botanical Gardens, Kew; British Museum, London; Museum d'Histoire Naturelle, Paris; University of Upsala, Sweden; University of Toronto, Canada; University of Copenhagen, Denmark; Mycological Collections, Bu. Pl. Ind., Washington, D. C.; State Museum, Albany, N. Y.; and Missouri Botanical Garden, St. Louis, Mo.

Prior to the beginnings of the writer's studies on this fungus in May, 1927 (apothecial collection No. *15602*), he had incidentally made two collections of the conidial stage in the vicinity of Ithaca, N. Y., one at Chicago Pond in July, 1906 (No. *2439*), and another at Taughannock Falls, N. Y., June 8, 1910 (No. *23272*). There is in the Atkinson (general collection) herbarium at Cornell University an unnumbered, undated collection by Bertha Stoneman made at Lakewood, N. Y., probably about 1898, under the name "*Gloeosporium* on *Podophyllum*."

In addition to these collections, there are now deposited in the herbarium of the Department of Plant Pathology at Cornell University, eleven collections of the conidial stage and nine of the apothecial stage, made by the writer and others in New York, Pennsylvania and New Jersey.

The only other collections known to the writer, in addition to those cited above in the discussion of the identity of our fungus, are two of the conidial stage in the Mycological Collections, U. S. D. A., Bur. Pl. Ind., Washington, D. C., one made at Morgantown, W. Va., June 21, 1928, and one at Cabin John, Md., June 3, 1930. In his search of herbaria in 1932 for early collections of this fungus, the writer sent specimens of the conidial stage to

a number of mycologists in this country and abroad, which are presumably to be found in their personal or institutional herbaria.

Other collections of the conidial stage are probably to be found in herbaria in this country. That collections of the apothecial stage have been heretofore made and preserved by others than the author is improbable. The writer would greatly appreciate records of any collections not referred to in this paper.

DISTRIBUTION

This fungus appears to be most common in a relatively narrow belt running west from the Atlantic seaboard to Missouri (Latitude 36–43° north). The host, which is a native of eastern North America, occurs from western Quebec and southern Ontario to Minnesota and Kansas, and south to Florida, Louisiana and Texas. As far as the writer has been able to discover, the fungus, which was originally collected (conidial stage) in Missouri in 1888 and again in 1903 (Maneval **1926**: 85), has been collected elsewhere only in Pennsylvania, Delaware, Maryland, West Virginia, New Jersey and New York. Our own observations indicate that it is most common here in the East in Pennsylvania and New Jersey. The writer has found it in but few stations in the neighborhood of Ithaca, and there in very limited areas. The most northern collection of which we know is the one made by Burnham on June 12, 1920, at Fort Ann, N. Y., in the upper Hudson River Valley. An extensive survey would probably disclose a more general occurrence of the fungus than the small number of records now indicate. The apothecial stage has been collected apparently thus far only in Pennsylvania, New York and New Jersey, but will doubtless be found where sought at the right time of the year (late April or early May) wherever the conidial stage is known to occur.

CULTURAL CHARACTERS

This fungus grows readily on potato dextrose agar at ordinary room temperatures. The optimum temperature for production of sclerotia appears to be between 18° and 24° C., varying with different isolates. Sclerotia appear in about 14 days at these temperatures.

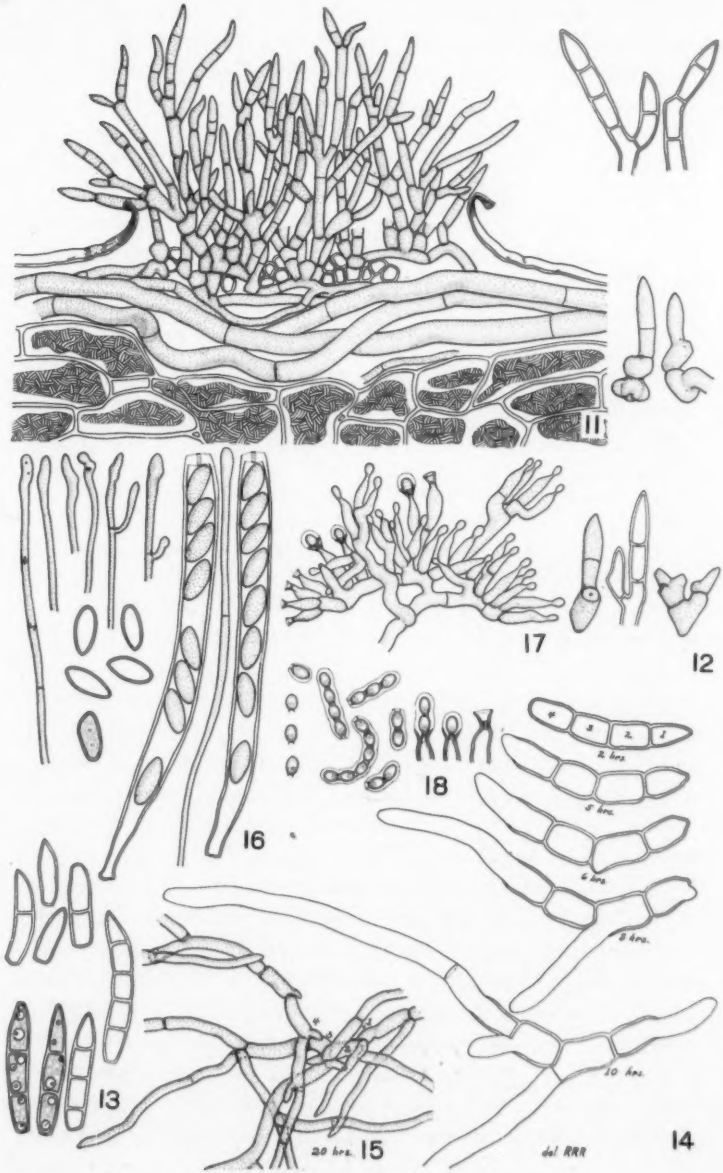
Single ascosporic isolates from any individual ascus give two different types of growth on potato dextrose agar (FIG. 9). For convenience in discussing them, they may be designated plus (+) strains and minus (—) strains. They occur in approximately equal numbers in random samplings.

The + strains are as a rule the more vigorous growers and have a slightly higher optimum temperature for sclerotial production. At 21° to 24° C. aerial mycelium is usually abundant, woolly, floccose or strongly tufted, at first white, eventually collapsing to form a yellowish-brown felt. In petri dish cultures thin, black, crust-like sclerotia, circular, oval or slightly irregular in outline, develop in 10–14 days; sometimes fusing to form large, irregular crust, especially at temperatures just below optimum; usually zonately disposed. Spermatia are present but not abundant. The medium is slowly and slightly or not at all discolored.

The minus strains, usually less vigorous than the plus strains, produce relatively little aerial mycelium, especially in the early days of growth. This is usually pruinose, sometimes with large scattered white tufts, quickly becoming a dark yellowish-brown in color and collapsing to form a dirty-brown felt. The optimum temperature for sclerotial production in most minus strains appears to be 15° to 18° C. Sclerotia are few or entirely wanting at temperatures above or below the optimum. Spermatia are usually abundantly developed. The medium is quickly and strongly discolored by the minus strains; at first of a bright cadmium-yellow, it soon turns to a dirty reddish-brown. The degree of medium-discoloration varies in the different minus isolates and is most pronounced at temperatures above the optimum for sclerotial production. At low temperatures (12°–9° C.) the discoloration usually shows a strong purple tint.

Single conidial isolates likewise give two types of growth on potato dextrose agar which are identical with the plus and minus strains described above. However, the isolates from any given lesion are all alike, either all plus or all minus, as is to be expected since each lesion usually represents a single ascosporic or a single conidial infection.

Mass cultures of ascospores or conidia give various combinations of the above-described characters of the plus and minus



FIGS. 11–18. *Septotinia podophyllina.*

strains, as is of course to be expected. The cultures, especially the minus strains, tend to "run out" (deteriorate or die out) at room temperature after several transfers. The characters above described are for recently isolated (one to two months old) strains. There is considerable individual variation in strains, both plus and minus, from the same apothecium or from a given conidial sporodochium.

This striking segregation of ascosporic and conidial isolates into two groups suggests that this fungus may be self-sterile ("heterothallic" *sic*), cross spermatization between plus and minus strains probably being necessary for production of apothecia from the sclerotia.

Conidial production has never been observed in artificial cultures, either from ascosporic or conidial sowings. Their development of conidia on agar is probably dependent on the proper slow drying of vigorously growing cultures.

PATHOGENICITY

Although no inoculation experiments have been undertaken, the evidence from the isolation work and field observations leaves no question in the writer's mind as to the pathogenetic relationship of this fungus to *Podophyllum*.

The lesions appear to be confined commonly to the leaf blades. They are usually initiated at some point within the margin of the blade, but in some cases at or near the margin itself. In an actively spreading lesion, the center of the necrotic spot is light brown, surrounded by a broad zonate area, the outer advancing zone of which is hydrotic. The margin of the lesion is more or less sharply defined. The mycelium just beneath the upper cuticle of the leaf forms white fans of radiating, rhizomorphic strands, most evident in the zone just back of that of the hydrotic margin (FIG. 4, 6). These whitish, fibrillose hyphal fans are a striking and characteristic feature of the lesions caused by this fungus.

The white conidial sporodochia are scattered over both surfaces of the lesion or gregariously localized here and there where conditions happen to be especially favorable to their development. They are usually most numerous on the upper surface of the lesion.

The leaflet or even the whole leaf may become completely involved and eventually wilt and hang dry and dead from the tip of the petiole.

LIFE HISTORY

When the diseased leaf eventually falls to the ground the fungus continues its vegetative activities in the dead tissues of the lesion, and spreads into the adjacent uninvaded parts of the blade. It now begins the accumulation of reserve foods into slender, angular (occasionally oval or circular), thin, black sclerotia which are formed most commonly along the veins and veinlets within the disintegrating leaves or along the upper third of the stalk. Coincident with the formation of the sclerotia, the spermadochia develop beneath the cuticle of the disintegrating leaves. These appear as minute, nearly microscopic, amber-colored bodies, often arranged in rows across the leaf (FIG. 5). The spermatia are produced in great numbers on these spermadochia in the manner characteristic of species of the Ciborioideae (FIG. 17). They doubtless function in the sexual fertilization necessary to the production of apothecia, as the work of Drayton (**1932**) on *Sclerotinia Gladioli* has shown. With final disintegration of the leaf tissues the sclerotia become buried in the soil and leafmold, there to remain until the following spring, when they give rise to the apothecia at the time the young leaves of the *Podophyllum* are expanding. Collection records of the apothecia indicate that they usually develop, in the region from Swarthmore, Pa., north to Ithaca, N. Y., from about the middle of April until the middle of May.

The ascospores are forcibly discharged into the air and, falling upon the young leaves when they are moist, germinate and infect them. The limited observations which the writer has made do not warrant a definite pronouncement as to the time elapsing between inoculation and the first evidence of infection. Collection records of the conidial stage indicate that well-developed lesions are abundant in a week or ten days after ascosporic inoculations. The earliest date on which leaf infections have been observed by the writer is May 15, 1936, at Labrador Lake, N. Y., ten days after apothecia in abundance were collected in the same area.

These lesions were so well developed, however, that they must certainly have been evident at least some days earlier.

The conidia doubtless initiate secondary cycles which would account for the actively developing lesions to be found in late June.

NOTES. There are several features of *S. podophyllina* which deserve special notice. The conidial stage is unique in the Ciborioideae, both as to the elongate-septate characters of the conidia and the sporodochial form of the conidial fruit-body. The structure of the sclerotium is typical of that of the botryoid species, the medulla consisting of relatively thin-walled hyphae embedded in a transparent gelatinous or horny matrix (FIG. 10), in contrast with the medulla of the true Sclerotiniae (*e.g., S. sclerotiorum*) in which the medulla is made up of densely interwoven, thick-walled hyphae but not embedded in a matrix. The spermatia, while borne on spermatiophores of the usual Ciborioideae type, and apparently in the manner described by Brierly (**1918**) for the spermatia of *Botrytis cinerea,* are markedly ovate instead of globose and present at their basal end a distinct stalk or collar. The gelatinous matrix in which they are embedded is exceptionally persistent, tending to hold the spermatia together in long chains even in water mounts (FIG. 18).

There is in the Herbarium of The New York Botanical Garden a specimen of a fungus on the ripening fruits of *Podophyllum peltatum,* collected by A. Commons (his number *598*) at Faulkland, Del., Aug. 8, 1887, the original label of which bears the name "*Gloeosporium fructigenum* B.?" Ellis, to whom the specimen was referred, added the note, "*Gloeosporium podophyllinum* E. & E. var. *fructigenum* E. & E. Spores broader than in *G. fructigenum.*" A careful examination of the specimen shows it to be a *Colletotrichum,* setae being present in great abundance. The fungus is quite distinct from the conidial stage of *S. podophyllina,* of which Ellis apparently regarded it a variety. The writer has found no published description of this fungus in the literature under this name. *Septotinia podophyllina* has never been observed on the fruits of its host, lesions apparently occurring only on the leaves and top of the stalk.

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EXPLANATION OF FIGURES

Fig. 1, individual apothecia attached to sclerotia; twice natural size; 2, clusters of apothecia as they occur where sclerotia are abundant on the ground; twice natural size; 3, sclerotia in rotting leaf; natural size; 4, conidial sporodochia on upper surface of leaf just back of the advancing margin of fan-like mycelium in the lesion; ten times natural size; 5, spermadochia beneath cuticle in rotting leaf; nine times natural size; 6, top view of lesion in leaf; note fan-like mycelium just back of advancing margin of lesion; natural size; 7, conidial sporodochia on upper surface of leaf; twice natural size; 8, top view of young lesion in leaf; natural size; 9, plantings of four single ascospore isolates on potato dextrose agar, grown at 24° C., 27 days old; the sector on the right is a typical minus strain; note absence of sclerotia and heavy aerial mycelium; medium strongly discolored a deep cadmium yellow; natural size; 10, freehand section through a sclerotium from leaf of the type collection, *25277*; note the embedded xylem vessels of leaf veins at *a*; enlarged 462 times; 11, a semi-diagrammatic longisection through a conidial sporodochium which originates just beneath the cuticle; magnification about × 300; 12, details of formation of conidiophores and conidia; magnification about × 550; 13, showing different forms, sizes and septation of conidia, with contents detailed in two of them; magnification about × 550; 14, showing progressive stages in the germination of a four-celled conidium at room temperature; cells numbered from apical to basal cell; magnification about × 550; 15, showing mycelial development from spore detailed in figure 14, 20 hours after beginning of germination; magnification about × 300; 16, showing details of asci, paraphyses and ascospores; magnification about 550; 17, semi-diagrammatic longisection through a spermadochium; magnification about × 850; 18, details of spermatia and spermatial formation; magnification about × 850.

NOTES AND BRIEF ARTICLES

G. R. Bisby, of the University of Manitoba, has left to take a position at the Imperial Mycological Institute, Kew, Surrey, England, beginning January 1, 1937.

The Perfect Stage of the Sour Orange Scab Fungus

The perfect stage of *Sphaceloma Fawcetti* Jenkins, the causal fungus of citrus scab, has recently been discovered on rind of Satsuma orange (*Citrus nobilis unshiu* Sw.) in São Paulo, Brazil, and is described in Phytopathology **26**: 393–396, 1936, as *Elsinoe Fawcetti* Bitancourt and Jenkins.

Three important mycological papers have recently appeared in the Studies in Natural History of the University of Iowa Studies: "Notes on the Lower Basidiomycetes" by Donald P. Rogers; "The Gasteromycetes of Iowa" by Paul E. Kambly and Robert E. Lee; and "A Key to the Families of Fungi Exclusive of the Lichens" by G. W. Martin. The latter is very convenient since it represents a concise treatment of the families of fungi. It also contains a glossary of some of the important mycological terms. Any of these papers can be obtained by addressing the Department of Botany, State University of Iowa.

Citrus Diseases and Their Control

A second edition of this authoritative work on the citrus diseases of the world has been published by the McGraw-Hill Company. The book has been completely revised and re-written by Prof. H. S. Fawcett, of the University of California, thus permitting the presentation of the abundance of new information in this field which has accumulated during the ten years that have elapsed since the appearance of the first edition. The inclusion of this new material has necessitated a very considerable enlargement of the book to 656 pages even though a number of illustrations used in

the original edition have been deleted. New sections have been added dealing with water rot, areolate spot, hard rot, Macrophomina root rot, red root disease, Ganoderma root rot, and a number of other new diseases. A new chapter on diseases due to deficiency and excess of inorganic constituents was written in collaboration with Dr. A. R. C. Haas. New sections on sweet-orange fruit scab, Australian citrus scab, and areolate spot were prepared in collaboration with Dr. Anna E. Jenkins. An outstanding feature is the comprehensive bibliography covering 42 pages which is more than double the space devoted to this feature in the first edition.—J. A. STEVENSON.

NOTE ON CONIDIOBOLUS

The appearance of *Conidiobolus villosus* Martin as a petri dish contaminant in the mycological laboratories at Cornell University seems worthy of mention here because of the evident rarity of the species and its association with a new substrate in a new locality. The species was described from Iowa by Martin (Bot. Gaz. **80**: 311–318. 1925) after it had appeared on a plate of agar during an attempt to secure a species of *Hypochnus* in pure culture. So far as the writer is aware there has been no further report of the species since the original publication.

On August 9 several apothecia of *Peziza domiciliana* Cooke, found in a cellar in Ithaca, were brought into the laboratory by a fellow student, E. W. Lyle. A portion of one of these was fastened to the lid of a petri dish over potato dextrose agar to obtain a spore shooting. Examination on the third day showed the area on which the ascospores had fallen to be overgrown by the contaminating organism, with a thin dusting of conidia on the lid about the bit of apothecium lying directly over this area. Growth of the *Conidiobolus* was rapid, and in a few days the inside of the cover of the dish was thoroughly dusted with white conidia. A second attempt to obtain a culture of the *Peziza* from apothecia collected in the same cellar a week later met with similar results.

The organism corresponds with Martin's fungus in being positively phototropic. Also it is in close agreement in all features of morphology, including size of the conidia and the transformation

of some of them into appendaged resting spores, which seem to be the chief characteristics of the species. Aside from the fact that the diminished average size of conidia in aged cultures—in some cases as low as 18 μ—is more marked than Martin's discussion would seem to imply, measurement of several hundred of them under various conditions furnishes no occasion for the recording of dimensions other than those which he gives.—W. L. WHITE.

At the annual summer conference of advisory plant pathologists at Leeds University, Dr. Geo. H. Pethybridge, Mycologist to the Ministry of Agriculture and Fisheries for the last twelve years, and previously for many years in the Department of Agriculture in Ireland, was—by over seventy present and former colleagues—presented with a wireless receiving set etc. as a mark of appreciation on the occasion of his approaching retirement from official service.—W. BUDDIN.